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FACILITY DECOMMISSIONING COST MODEL

Summary of Model and Supporting Documentation

Revision 3

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Executive Summary

In fiscal year 1998, an intensive effort was undertaken to improve the basis and validity of the decommissioning cost estimate for the closure of the Rocky Flats Environmental Technology Site (RFETS). The product of this effort was the Facility Decommissioning Cost Model[1] (FDCM). The FDCM generates a parametric order-of-magnitude cost estimate for the decommissioning of all buildings and facilities at the RFETS by the end of calendar year 2006. Since its initial publication in August 1998, there have been four revisions of the FDCM of which Revision 3 is the latest – see Table 1.1.

A standard work breakdown structure (WBS) used in the FDCM for decommissioning activities provides an organized framework for the estimate. The FDCM relies heavily upon actual cost data from the decommissioning of facilities at Rocky Flats to develop unit costs for the decommissioning activities. When Rocky Flats decommissioning experience is not available, the model uses RFETS bottoms up estimates, actual cost experience, or bottoms up estimates from other government and commercial facilities. Unit quantities included in the model were obtained from the Facility Disposition Program Manual (FDPM) and the Rocky Flats Closure Projects Facility List. Additional information on gloveboxes, piping and duct costs, internal tanks, external tanks, and building footprint areas are based upon current RFETS information.

Revision 3 of the FDCM incorporates all the Revision 2/2A changes and the most current actual cost information from the decommissioning of the 207 Cluster (B788) and the 779 Cluster. In addition, Revision 3 includes costs for the decommissioning of facilities previously excluded from the FDCM, i.e., railroad tracks and crossings, water storage ponds, security and perimeter fencing, and external building and perimeter lighting. In previous revisions of the FDCM, the decommissioning costs of the aforementioned items were included under Environmental Restoration (ER) and therefore were not covered by the FDCM. Revision 3 estimates the total direct costs to decommission all the RFETS facilities listed in Appendix A to be approximately $910.25M. This is about $105.73M more than the decommissioning costs shown in Revisions 2/2A – see Appendix K for details. The primary reasons for the increase is the increased Type 3/3CA (T3/T3CA) and Type 2/2CA (T2/2CA) building unit costs, increased glovebox decommissioning costs, and increased unit costs for T1 and T2 buildings located inside the PA. These increases incorporate the experience and lessons learned from the decommissioning of the 779 cluster and, to a lesser extent, relevant B788 experience – see Appendix L. The 779 cluster was the first T3 building/cluster with associated T1 and T2 support facilities decommissioned at RFETS and in the DOE Complex. Although few in number, the T3 buildings represent about ***tbd***% of the total RFETS decommissioning costs and therefore any changes in their unit cost has a profound effect on the total estimated decommissioning costs for the Site.

Given the expected complexity and uncertainties associated with decommissioning the Site by 2006, the FDCM includes a detailed cost uncertainty analysis to quantify a reasonable level of contingency – see Appendix I. Based on this analysis, the decommissioning direct cost Estimate at Completion (EAC) is projected to be *$**tbd**M* (Base Cost plus ***tbd****%* contingency).

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[1]Prior to Revision 3, it was called the Facility *Disposition* Cost Model

Table 1.1. FDCM History

Rev	Date Issued	Base Cost[1] ($M)	Contingency ($M)	Total ($M)	General Remarks
0	Aug, 98	881.21	299.00	1,180.21	2010 Baseline, 33% contingency, B123 ACWP, no cost reductions, e.g., learning curve included
1	Jan, 99	881.21	299.00	1,180.21	Text changes and revisions only
2	May, 99	804.52	160.48	965.00	2006 Baseline, 20% contingency, scope changes/additions, include T1and T2 learning curve, other cost reductions
2A	Sept, 99	804.52	160.48	965.00	Text changes and revisions only
3	April, 00	910.25	***tbd***	***Tbd***	2006 Baseline, ***tbd***% contingency, scope additions, includes 779 and 788 ACWP, includes all cost reductions from FDCM Revision 2/2A

[1]Base costs are constant for the year shown, prime, and unescalated.

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SECTION 1.0
INTRODUCTION

This document provides Revision 3 of the D&D Project's Facility Decommissioning Cost Model (FDCM) and its requisite supporting information. The FDCM generates an order-of-magnitude estimate of the post FY 2000 RFETS direct (unburdened and unescalated) decommissioning costs using available physical parameters, e.g. building area, and actual and estimated decommissioning unit costs. Order-of-Magnitude estimates are, by definition, based on limited qualitative and quantitative information and are therefore subject to considerable variation. For estimates of this caliber, actual costs are expected to vary within a range of plus 50 percent to minus 30 percent from their estimated values.[1]

Revision 3 of the FDCM includes the following major scope changes and additions, deletions, and all the previous changes and cost reductions from Revision 2/2A:

- As appropriate, Revision 3 incorporates changes in the building unit costs, based on the Actual Cost Work Performed (ACWP) incurred in the 207 and 779 cluster decommissioning projects, and 779 lessons learned. (The results of an independent cost assessment of the 779 ACWP and Estimate at Completion (EAC) is found in Appendix L.)

- Major scope additions include costs for the removal of Site railroad spurs and crossings, perimeter and security fences, storage water pond hardware, and Site external facility and perimeter lighting. In previous revisions of the FDCM, the cost for decommissioning these facilities and structures was considered to be the responsibility of Environmental Restoration (ER) and therefore were not included in the FDCM.

- A crosswalk of the changes in costs between Revision 2/2A and Revision 3 is found in Appendix K, Table tbd.

- Supports the Site Closure target of 2006.

As in all previous revisions to the FDCM, Revision 3 includes the results of an uncertainty range analysis. The range analysis is used to develop a reasonable contingency that is to be applied to the estimated decommissioning costs generated by the model. The indicated range of contingency, coupled with the forecasted costs generated by the FDCM, facilitates the selection of a high confidence level total estimated cost of decommissioning.

[1] American Association of Cost Engineers, *Skills and Knowledge of Cost Engineering*, Third Edition (Revised).

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SECTION 2.0

MODEL OVERVIEW

2.1 CONCEPTUAL FRAMEWORK

The FDCM estimates the costs for the decommissioning of all types of facilities including buildings, trailers, tents, cooling towers, tanks, and other facilities at RFETS using a top-down model based upon empirical data. In the FDCM, all facilities at RFETS are classified by type; each facility is assumed to have the requirements and characteristics typical of all other facilities of that type. Because all facilities are atypical in some sense, adjustments are made to incorporate special features or characteristics, e.g., type of construction, assumed levels of contamination, gloveboxes, piping, ducts, and internal tanks. The model relies on the best currently available information describing the physical dimensions and characteristics of the facilities at RFETS and, to the extent possible, actual RFETS decommissioning cost experience. The following sequence of steps describes the process used to develop the FDCM.

- **Identify Key Assumptions**: Important assumptions were identified early in the model development process to bound the model. Other assumptions were established during the course of developing the model. Section 3 outlines these assumptions.

- **Establish the Work Breakdown Structure**: A standard decommissioning work breakdown structure (WBS) and supporting WBS dictionary were developed to organize the estimate into a logical framework. The decommissioning WBS is a component of and is consistent with the RFETS Closure Project WBS. Section 5 provides details on the WBS.

- **Classify the Facilities and Buildings**: The facilities were classified by types to standardize the estimating process. This classification structure is described in Section 6.

- **Collect Physical Information on the Facilities**: The best available current building and facility information was collected. Much of this information comes from the Facility Disposition Program Manual (FDPM) and the <u>Rocky Flats Closure Projects Facility List</u>, which is the official source of facility and building information at RFETS. Additional quantity information was collected from a variety of sources within the Site. More details on the facilities and the sources of facility information can be found in Section 6 and Appendix A.

- **Identify Unit Costs and Resources**: Actual RFETS decommissioning costs were collected, analyzed, and normalized for use in the model. <u>Where available,</u> cost data gaps were filled with detailed bottoms up cost estimates or with actual costs from comparable government or commercial decommissioning projects. Section 7 discusses costs and resources.

- **Identify and Quantify Project Uncertainties**: A detailed range estimate was developed at the decommissioning element/activity level. Section 8 discusses the contingency analysis.

- **Load Information into BEST System**: All of the data developed for the FDCM were loaded into the Basis of Estimate Software Tool (BEST) System. Section 4 describes the BEST system.

- **Model Improvements**: A number of recommendations for future revisions of the model have been identified. Section 10 discusses these recommendations.

2.2 SOURCES OF INPUT DATA

2.2.1 Facility Information

The list of RFETS facilities and their descriptions in Appendix A (total area, etc.) was extracted from Appendix B-2 of the Facility Disposition Program Manual (FDPM). Other sources of building data used are the Rocky Flats Closure Projects Facility List, Building Final Safety Analysis Reports (FSARs), and various building structural analysis reports which contain building descriptions and construction details. Existing RFETS databases are the source of additional information on gloveboxes, piping/ductwork, tanks, and other ancillary components.

2.2.2 Cost and Resource Information

The FDCM uses cost information from various completed decommissioning projects or activities at RFETS to develop unit costs. When actual RFETS costs are not available, the model uses costs based on detailed bottoms up estimates or actual costs from comparable government or commercial decommissioning projects. In some cases, the FDCM applies adjustment factors to actual cost information to account for differences in types of facilities. These factors are based on actual experience or on detailed analyses. The major sources of decommissioning cost information by type of building are listed below.

- **Buildings:** Actual decommissioning costs were gathered from the decommissioning of Buildings 123, 889, 788, and 779 and the on-going work in Buildings 771, 371, 707, and 778. Factors were developed to address the different levels of assumed contamination and different types of building construction.

  - **Gloveboxes:** Glovebox dismantlement costs per unit volume are based on actual cost experience from the decommissioning of 133 gloveboxes in Building 779.

  - **Piping, Ducts, and Internal Tanks:** The estimated costs for the decommissioning of the piping, ducts, and internal tanks (PD&T) are based on actual decommissioning cost data from Building 779. A primary assumption of the FDCM is that, until additional cost information and/or planning informational is available from other Type 3 buildings, the PD&T costs for Building 779 will serve as the benchmark for estimating the PD&T costs for all Type 3 buildings and the four selected Type 2 buildings.

- **Trailers**: The basis of the cost estimate for the decommissioning of trailers is the actual cost data collected for decommissioning the T690 and T112 cluster trailers.

- **Cooling Towers: The** cost estimate basis for decommissioning cooling towers constructed on site is based on the estimated decommissioning costs for a T1 modular building with a T2 slab.

- **Tents:** Decommissioning cost estimates for tents are based on an adjusted estimate developed for the removal of four tents located in the 904/906 Cluster.

- **External Tanks:** The cost basis for external tank decommissioning is actual cost data obtained from the decommissioning two large fuel oil storage tanks (Tanks 221 and 224), two acid tanks (Tanks 218-1 and 218-2), and 779, 788 experience.

- **Pads and Slabs: The** decommissioning cost basis for pad, slab, and foundation removal is based on the cost for removing slabs in *Richardson Engineering Services, Inc. adjusted* for the RFETS work environment.

- **Railroad Spurs and Crossings:** The decommissioning costs for removal of Site railroad spurs and crossings is based on RFETS adjusted cost data from *Richardson Engineering Services, Inc* for removing similar structures.
- **Perimeter and Security Fencing:** The decommissioning costs for removal of chain link perimeter and security fencing is based on RFETS adjusted cost data from *Richardson Engineering Services, Inc* for removing similar structures.
- **Water Storage Ponds:** The decommissioning costs for removal of the ancillary hardware and piping from the Site's water storage ponds is based on RFETS adjusted cost data from *Richardson Engineering Services, Inc*.
- **External Facility and Perimeter Lighting:** The decommissioning costs for removal of external perimeter and facility lighting is based on RFETS adjusted cost data from *Richardson Engineering Services, Inc* for removing similar utilities and services.

2.3 INTERFACES TO OTHER RFETS ACTIVITIES

There are several critical interfaces between the direct labor and non-labor decommissioning costs that the FDCM estimates and the non-decommissioning costs that are outside the scope of the FDCM (and are therefore not included). These include the following important interfaces:

2.3.1 Deactivation – Decommissioning Interface

By definition, the FDCM contains no scope or costs associated with deactivation. Deactivation activities include but are not limited to:

- Removal of all combustibles that are not an integral part of a facility.
- Removal of classified and unclassified equipment, materials, and furniture.
- Removal of containerized SNM, process liquids and residues, and SNM.
- Removal of plutonium holdup in ducting and equipment that can be removed without compromising the confinement system.
- Removal of other hazards as required to place the facility in a safe and stable condition
- Preliminary characterization of the building and its contents to identify the above items.
- Size reduction, preparation, and packaging when required of the above material.
- Direct labor and non-labor costs including, but not limited to, the general management activities of the building such as the preparation of the Project Execution Plan, if required for Deactivation, general administrative work, PM/CM reviews, presentations to management, documentation, controlling, and reporting.

- Direct labor and non-labor costs for support activities including, but not limited to, landlord, security, analytical laboratory, document control, quality, procurement, engineering, industrial hygiene, etc.
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2.3.2 Waste Management - Decommissioning Interface

The FDCM Cost Model contains no scope or costs associated with waste management except as noted below. Costs are included in the model (under dismantlement) for: (1) size reduction of building materials and contents, if required; (2) packaging waste in the proper container according to Waste Acceptance Criteria and placement in a designated pickup/staging area; (3) acquisition cost of decommissioning required waste containers; and (4) if required, the transportation of compliant stored waste to the nearest designated RFETS waste storage area/facility or pickup point;. No subsequent costs for the treatment, storage, transportation, or disposal of waste generated by decommissioning activities are included. However, costs are included in the model (under demolition and disposal) for the disposal of clean building rubble and debris in a sanitary landfill.

2.3.3 Landlord - Decommissioning Interface

By definition, the FDCM contains no scope or costs associated with landlord activities. Landlord activities include:

- Compliance and Surveillance
- Facility Maintenance
- Facility Operations
- Technical Support
- Operations management of the facility, utilities, and support systems
- Facility Closeout
- Utilities required to support ongoing building activities and deactivation
- NOTE: The transition and phase out of Landlord activities of the various buildings and clusters will be developed on a building-by-building basis.
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2.3.4 Environmental Restoration – D&D Interface

Revisions 0 and 1 of the FDCM did not include estimated costs for removal of on-grade or below grade structural components, i.e., concrete slabs, foundations, and footings associated with the decommissioning of buildings. This work was previously considered to be within the scope of Environmental Restoration (ER); however, in Revision 2/2A of the FDCM, decommissioning costs for the removal of on-grade and below grade structural components were included. The on-grade and to three feet below grade structural components will be removed as part of the overall decommissioning effort. The remediation of contaminated soils found beneath the on-grade or below-grade structural components or exposed due to the removal of these components will be accomplished as part of the ER effort. The transition from decommissioning to ER is intended to be a seamless transfer of responsibility.

For Revision 3 of the FDCM, costs are included for the removal of railroad spurs and crossings, perimeter and security fencing, storage water ponds, and the Site's external facility and perimeter lighting. In previous revisions of the FDCM, the costs for decommissioning these items were considered to be the responsibility of Environmental Restoration (ER) and therefore were not included in the FDCM.

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SECTION 3.0
ASSUMPTIONS

This section documents the assumptions used to develop the FDCM. These assumptions have a direct and significant influence on the outputs from the model. The purpose of the FDCM is to provide a forecast of the RFETS decommissioning costs based on physical dimensions, e.g., the area or volume of facilities. As such, forecasted decommissioning costs of individual buildings/facilities or labor resources associated with individual decommissioning WBS elements or buildings can vary widely. The costs developed by the FDCM represent the “average case”, not the expected cost of any individual item.

3.1 GENERAL ASSUMPTIONS

- All costs are in unburdened (direct), constant fiscal year 2000 dollars. No escalation or contingency has been applied to the estimate.
- Costs in the FDCM cover only decommissioning activities. No costs are included for Landlord, Hazard Reduction/Stabilization, SNM Removal, Deactivation, Environmental Restoration, or Cluster Closure except as noted.
- The schedule for facility decommissioning is based on Revision 8 of the 2006 Facility Disposition Plan (Eye Chart) – see Attachment 1.
- Time dependent decommissioning cost correction factors are those factors that relate a change in the decommissioning cost to a specific assumed point or points in time when or after which certain decommissioning related actions are slated to occur. Decommissioning cost correction factors have been incorporated into the cost estimates in Revision 3 of the FDCM. These factors cover the approval for use of RFCA Standard Operation Protocols (RSOPs), the relaxation and removal of Protected Area (PA) and Material Accountability Area (MAA) entry requirements, workers becoming more familiar and experienced with repetitive decommissioning related activities (Learning Curve), the Centralized Waste Reduction Facility (CWRF) becoming operational, and the approval by the Colorado Department of Public Health and the Environment (CDPHE) for RFETS to use Dose Based Radiation Exposure Standards. The relationship between the decommissioning work and the appropriate date are based upon Revision 8 of the Facility Disposition Plan (Eye Chart).
- All decommissioning activities are conducted in accordance with existing RFETS practices, RFETS labor agreements, and current regulatory structure as of April 2000.
- Required RFETS infrastructure will be in place to support all decommissioning activities. No funding constraints are assumed in developing the schedule or cost estimates.
- Current technologies will be sufficient for decommissioning.

- The FDPM and the Rocky Flats Closure Projects Facility List databases are used as the primary sources for identifying the facilities included in the FDCM and basic facility/building parameters, e.g. building area, assumed contamination level, year of construction, etc.

- Both contaminated and non-contaminated areas have been identified within eleven of the 66 Type 2 (T2) buildings and the six remaining Type 3 (T3) buildings. Contaminated areas (CAs) are the processing or production areas of buildings. The non-contaminated, or "clean" (non-CA) areas, of a building include areas such as administrative or office areas, lunch rooms, etc. The CA and non-CA areas of the individual buildings were determined by the Radiological Engineering Group and presented to DOE in an RFETS Radiological Areas Site-Wide report. This report is used as the source for defining the CA and non-CA areas. Buildings that have identified contaminated areas are identified in Appendix A.

- Based on the decommissioning of the 779 Cluster, two different unit cost templates have been developed and incorporated for T1 and T2 buildings. These templates recognize and take into account the differences in decommissioning unit costs for T1 and T2 buildings located inside the PA. as opposed to those located outside the PA.

- The time dependent correction factors for implementation of RSOPs (RFCA Standard Operating Protocols), removal of Protected Area security access restrictions, learning curve, and implementation of the Centralized Waste Reduction Facility, are based on Revision 8 of the 2006 Facility Disposition Plan (Eye Chart) - see Attachment 1.

- The proposed Decommissioning Acquisition Strategy is presented in Appendix D, Table D-15. The overall decommissioning work effort is divided or split on a percentage basis between the K-H Team and subcontractors. This split is based upon prior RFETS experience and SME input. For the fixed price subcontracted decommissioning effort cost element code (CEC) A5B, it is assumed that all subcontract costs are included in the subcontract dollar value. For the K-H Team and subcontracted services (CEC A5H), it is assumed that the management and supervision costs are identified within the CEC A5H for the decommissioning support subcontractors or within the K-H Team straight time basis (CEC 750). All costs for material, supplies and equipment used by the support services subcontractors and/or the K-H Team are assumed to be included in supplies (CEC A5C).

- Adjustments are included to account for economies of scale for multistoried buildings. These economies of scale are based on the assumption that increasing the area of a building by adding a second floor or basement does not proportionally increase the cost of most of the decommissioning elements. A more complete discussion of the economy of scale factors is in Section 7.

- A distinction is made between trailers installed before and after the site ceased production in 1989. Trailers installed in 1989 or later have not been exposed to the same potential levels of contamination as trailers installed prior to 1989. The costs for decommissioning trailers have been adjusted accordingly and are discussed in detail in Section 7.

- Time-phased decommissioning cost reduction fractions for buildings and gloveboxes are included in Revision 3 of the FDCM in accordance with Tables K-5 and K-6 in Appendix K.

- All surplus materials or equipment generated by decommissioning and released for disposal or uncontrolled use will meet all RFETS radiological contamination requirements applicable at the time of removal.

- Building concrete demolition rubble and debris contains no asbestos residues.

- The cost and schedule impacts associated with beryllium contamination are assumed to be equivalent to those impacts associated with T2 Facility uranium contamination.

3.2 UNIT COST FACTOR SPECIFIC ASSUMPTIONS

3.2.1 Planning and Engineering

- In general, decommissioning Planning and Engineering costs are based on a percentage of total project cost. This percentage is based on actual experience at RFETS for the planning and engineering of comparable projects. The basis of these factors is described in Section 7.

3.2.2 Characterization

- An allowance of $1.50/ft^2 for miscellaneous Materials, Supplies, and Equipment (MS&E) is assumed for all building types and is included in the characterization unit cost. This amount was identified as a result of the analysis of Building 123 and 779 Cluster decommissioning costs.
- The model assumes a direct functional relationship between characterization and dismantlement.

3.2.3 Site Preparation

No additional unit cost assumptions have been identified for this WBS cost element in FDCM Revision 3.

3.2.4 Decontamination

- All asbestos removal and lead abatement costs are included under Decontamination.
- The asbestos removal subcontract costs for the B889 and B123 decommissioning were approximately $29.00/ft^2. These costs also include the cost of remediating lead. Buildings 123 and 889 are assumed to be comparable to all other buildings at RFETS with asbestos contamination. This value is assumed to be constant for all building types. Nominal contamination removal unit costs of $2.00/ft^2 were assumed for all T1 and T2 buildings located outside the PA and whose construction began after 1979. These nominal decontamination allowances were increased to $4.00/ft^2 and $3.00/ft^2 for T1and T2 buildings located inside the PA. These allowances are primarily for RFCA survey requirements and possible remediation of other hazards such as lead that may be present.
- An allowance of $2.00/ft^2 for miscellaneous MS&E is assumed for all building types and included in the decontamination unit cost.
- The decontamination costs for gloveboxes, piping, ducts, and internal tanks in process areas of buildings are not included in the decontamination costs of the building. The decontamination costs for these items are included under Dismantlement.
- The model includes the cost of size reduction, packaging, and preparation for shipment of wastes generated during Decontamination. The model also includes all pre-certification costs incurred prior to transferring responsibility for material to Waste Management.

- No specific costs for removal of beryllium (Be) are included in the FDCM.

3.2.5 Dismantlement

- The security clearance level for building trades in Type 3 buildings will be the same as that used for decommissioning B123 (i.e. no security clearance requirement).
- Direct unit costs for dismantlement of Type 3 and designated Type 2 buildings do not include dismantlement costs for gloveboxes, process piping, ductwork, and internal tanks containing process materials.
- Dismantlement unit cost estimates increased significantly across the three building types. These increases were assumed to account for the removal of process equipment, additional glovebox ties to process piping, alarms instrumentation, and additional HVAC (Zone 1/Zone 2) removal. These factors are documented and described in Section 7.
- An allowance of $1.00/ft^2 for miscellaneous materials, supplies, and equipment is assumed for all building types and included in the dismantlement unit cost.
- The Dismantlement costs for piping, internal building tanks, and ductwork in other than T3 and selected T2 buildings are included in that building's unit costs. For reporting purposes, the costs for the aforementioned items in the contaminated areas of T3 and selected T2 buildings will be shown separately under the Dismantlement WBS element. For the remaining six T3 and four T2 buildings, the decommissioning costs for their process piping, internal tanks, and ductwork is calculated and reported as a separate line item in the FDCM.
- Process piping, ducts, and internal tanks, include, but are not limited to, such systems as process and fire protection water; pencil and annular tanks; nitrogen, argon, steam, condensate piping; etc. Included in the ductwork are such systems and items as the glovebox support ductwork, process area HVAC systems, Zone 1 plenums, etc.
- The dismantlement of gloveboxes includes the glovebox as well as electric equipment, pumps, piping, and ductwork that are part of the integral structure of the glovebox. The piping and ductwork terminates at the first flange or connection outside of the glovebox. Electrical equipment that is connected to the glovebox, but is not bolted or otherwise permanently attached to the glovebox is not considered part of the unit and is removed during Deactivation or Dismantlement.
- Glovebox removal direct unit cost of $929 per cubic foot of contaminated glovebox is based on the actual direct costs for decommissioning 133 gloveboxes in Building 779. More details on glovebox costs and assumptions can be found in Appendix E and Appendix L.

3.2.6 Demolition and Disposal

- All buildings are classified into four construction types: modular, masonry, reinforced concrete, and massively reinforced concrete. The unit costs for demolition and disposal are adjusted according to these construction types.
- Based on demolition survey results, costs are included in the model for shipment and disposal of all uncontaminated building rubble in a sanitary landfill.

- No allowances or adjustments to the estimate for any scrap/salvage sales or recycling of uncontaminated facility debris (equipment, ducts, etc.) are included.
- The decommissioning costs for building pad, slab, and foundation removal, railroad spurs and crossings, perimeter and security fences, storage water ponds, and Site external perimeter facility lighting are included under Demolition and Disposal. In addition, costs for backfilling, grading, compaction, and revegetation, if applicable, are included under this WBS element.

3.2.7 Project Management

- The increase in decommissioning Project Management (PM) cost across the three building types accounts for the additional PM resource requirements, DOE, K-H Management, and stakeholder reviews, and increased oversight costs which occur as the building type progresses from a Type 1 to a Type 3.
- If decommissioning work is awarded in a fixed price subcontract, the subcontractor project management costs are included in the fixed price bid.

3.2.8 Support Services

- No additional unit cost assumptions have been identified for this WBS cost element in FDCM Revision 3.

3.3 EXCLUSIONS

3.3.1 Excluded Facilities

Estimated costs to decommission the following types of facilities are excluded from the FDCM:

- Radio, climatology, and air monitoring towers
- Air and water sampling/monitoring stations
- Valve vaults
- Roads, parking lots, miscellaneous asphalt pads, sidewalks, and storage yards
- Water, gas, steam, and electrical distribution systems (including power poles), sanitary sewer lines; and communication systems
- Overhead pipe lines and building steam heating lines
- Bus stop and van pool shelters
- Cargo containers
- Foamed-in-place underground storage tanks
- Concrete and asphalt pads and slabs not located under existing buildings
- Water Storage Ponds (except as noted in Section 6.7 *Other Facilities*)

3.3.2 Excluded Costs

Costs for the following non decommissioning activities are excluded from the FDCM:

- Landlord activities including:
  - Cluster Compliance and Surveillance
  - Baseline Maintenance
  - Operations Management
  - Technical Support
  - Maintenance and operations required for continued operation of exhaust fans, utilities, and other building support systems required for decommissioning.
  - Personnel Relocations
- Environmental Restoration, e.g., Remediation of High Risk IHSSs, and the excavation and disposal of contaminated soil except as noted in 2.3.4.
- Any special security requirements needed for uncleared personnel to perform work, e.g., work inside the Protected Area (PA).
- Providing support services to decommissioning subcontractors, e.g., laundry services.
- Deactivation activities including the removal of classified equipment and tooling, containerized SNM and process residues, and plutonium (Pu) holdup in ducting and equipment that can be removed without destroying the confinement system, disposition of excess property and chemicals, disposal of old files. Characterization activities during deactivation include a preliminary characterization of the building process equipment to identify initial quantities of Pu.

- Stabilization and Hazard removal activities. Stabilization and Hazard Removal actions remove a facility from operation and prepare it for turnover for decommissioning. Specific Stabilization and Hazard Removal activities include but are not limited to: developing work plans and Integrated Work Control Packages (IWCPs); performing pre- and post- action walkdowns to determine the “as-found” and “as-left” conditions; inventory and removal of documentation, chemicals, other hazardous and non-hazardous materials, equipment, supplies, and tank holdup; and emptying administrative and storage areas of furnishings and materials. Activities may also include transfer of materials and equipment possessing economic value to PU&D.

- The end-state of Stabilization and Hazard Removal is achieved when the facility has been placed in a safe, stable condition with minimal mortgage costs while awaiting decommissioning actions.

- Cluster Closure activities.

- Any K-H Team performance measure fee costs.

- Any costs associated with the acquisition, installation, startup, operating, and maintenance of advanced reduction technologies/facility,

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SECTION 4.0

APPLICATION OF BEST SYSTEM FOR THE FDCM

This section describes the method for entering FDCM data in the Basis of Estimate Software Tool (BEST) System to obtain summary and total decommissioning cost estimates. Appendix H contains a general description of the BEST software.

BEST input templates were developed for each type of facility. These templates include the capability to account for the varying parameters within each type of facility, (i.e. construction type, pre-1980 for asbestos, etc.). The templates were developed with a combination of labor hours and subcontract dollars applicable to a nominal dimension (area or volume) that combine a typical mix of labor (both salaried and hourly), materials, and supplies consistent with the unit costs provided by the FDCM.

The FDCM provides the quantity, factors, and unit cost data to calculate decommissioning costs. The unit quantities (building total area and footprint area, glove box and tank volumes, etc.) for each facility are entered as the quantity of work to be performed for each decommissioning activity. Using these data, BEST calculates the total cost of the resources for each decommissioning activity for each facility.

In order to incorporate FDCM Revision 3 changes, unit cost data associated with multi-story buildings, and time dependant factors into BEST, the concept of “Equivalent Areas” was replaced <u>by an “Adjusted Factors” concept. This concept maintains the area of a facility (square feet) as a constant and applies time dependent discount factors, e.g., learning curve to the facilities unit cost. The correction factors used for the FDCM Rev. 3 Decommissioning Cost Estimate are shown Appendix K.</u>

Unit Cost x Adjustment Factor(s) x Number of Units = <u>FDCM Cost</u>

All activities are entered into the BEST System by fiscal year, and Primavera Program Planner (P3), the RFETS planning and scheduling system, is used to produce resource loaded time phased cost plans. Escalation may be applied to the total project costs; however, the costs in the FDCM are constant FY2000 prime dollars.

An added benefit to this approach to estimate the total time-phased cost to decommission all the facilities at RFETS is that it also provides an estimated time-phased projection of future labor and subcontract resources required for the decommissioning work.

5

SECTION 5 WORK BREAKDOWN STRUCTURE

A standard decommissioning work breakdown structure (WBS) was developed to organize decommissioning cost estimates. This generic WBS for all decommissioning projects is shown in Table 5.1 below. All decommissioning projects will be planned in compliance with applicable and relevant internal and external requirements in recognition of end state and at a commensurate level of detail using a graded approach. A graded approach to planning recognizes and considers such factors as the importance to safety, environmental/regulatory compliance, current level of knowledge, safeguards and security, programmatic importance, magnitude of the hazard, financial impact, and other facility or project specific requirements.

Table 5.1. Decommissioning Work Breakdown Structure

WBS ELEMENT NUMBER	WBS ELEMENT TITLE
1.1.XX.YY.04.01	Planning and Engineering
1.1.XX.YY.04.02	Characterization
1.1.XX.YY.04.03	Site Preparation
1.1.XX.YY.04.04	Decontamination
1.1.XX.YY.04.05	Dismantlement
1.1.XX.YY.04.06	Demolition and Disposal
1.1.XX.YY.04.07	Project Management
1.1.XX.YY.04.08	Support Services

Sections 5.1 through 5.8 describe the activities in each of the eight elements of the decommissioning WBS

5.1 PLANNING AND ENGINEERING

As applicable, this element addresses all the task specific direct labor, equipment, materials, supplies and subcontract (A5X) costs for the Planning and Engineering of decommissioning projects. The scope of this element includes, but is not limited to, activities such as: the preparation of the Decommissioning Project Execution Plan (PEP), Decommissioning Operations Plan (DOP), Proposed Action Memorandum (PAM), Interim Measures/Interim Remedial Actions Document (IM/IRA), RCRA Unit Closure Plan, Health and Safety Plan (HASP), preparation of work plans to the Integrated Work Control Procedure (IWCP), Quality Assurance Plan (QAP), project-specific WBS, readiness assessments, Management Reviews, Waste Management Plan, Training Plan, utility relocation design documents, building demolition design documents, equipment removal design documents, design engineering inspection, preparation of required procedures and protocols; e.g., Quality Assurance/Quality Control (QA/QC) procedures, RFCA Standard Operating Protocols, preparation and submittal of all permits; e.g., APENs, etc.

5.2 CHARACTERIZATION

As applicable, this element addresses all the task specific direct labor, equipment, materials, supplies and subcontract (A5X) costs for characterization of decommissioning projects. Under the characterization WBS element, costs shall be collected under the following sub-categories: Scoping and Reconnaissance Level Characterization and the Final Characterization Survey, which includes independent verification, if required, for the D&D Closure Projects. This element would not cover the characterization associated with In-Process Characterization during the execution of the Decontamination, Dismantlement, and Demolition and Disposal WBS elements. As appropriate, In-Process Characterization costs would be charged to the aforementioned WBS work element it supports. In addition, this element would not cover the characterization associated with UBC, PAC, or IHSS remediation, which is part of Environmental Restoration (ER).

5.3 SITE PREPARATION

As applicable, this element covers all the task specific direct labor, equipment, materials, supplies and subcontract (A5X) costs for site preparation of decommissioning projects. The scope of this element includes, but is not limited to, activities such as: the establishment of tool cribs, laydown, shipping and material processing areas; set-up of size reduction, monitoring and waste/material staging areas; and, if required, the transportation of existing compliant stored waste to the nearest designated RFETS waste storage area/facility or pickup point. Any costs to make non-compliant existing stored waste compliant are a Waste Management responsibility and are therefore not included in the FDCM.

5.4 DECONTAMINATION

As applicable, this element addresses all the task specific direct labor, equipment, materials, supplies and subcontract (A5X) costs for decontamination of decommissioning projects. The scope of this element includes, but is not be limited to, the decontamination of building interior/exterior surfaces, equipment, drains, etc. In addition, it includes the removal of hazardous and toxic substances; e.g., asbestos abatement, lead/lead based paint and PCB removals, etc. associated with the decommissioning effort. This element also includes the costs associated with packaging, pre-certification[2] and movement to the nearest RFETS designated pickup point; i.e., building loading dock, etc., of contaminated wastes/materials generated during the overall decontamination effort. Any additional movement or treatment, storage and disposal (TSD) of contaminated (hazardous and/or radiological) materials, after they have been packaged and staged at the pickup point, for the types of hazardous and/or toxic wastes generated as a result of the overall decontamination effort are not included in this element. These waste disposal costs are the sole responsibility of Waste Management (WM).

> *NOTE: The decontamination specifically associated with the removal of gloveboxes, internal tanks, process piping, and Zone 1 HVAC ducting is included in the Dismantlement element below.*

[2] Pre-certification of waste materials is defined as that degree or amount of waste inspection and certification required, on the part of the specific D&D Project, to ensure that there is a reasonable probability that the packaged wastes will not be returned to the project for additional work. Pre-certification does not involve the more sophisticated techniques of waste certification such as, NDA, headspace sampling, etc. These sophisticated certification techniques are the responsibility of Waste Management (WM).

5.5 DISMANTLEMENT

As applicable, this element addresses all the task specific direct labor, equipment, materials, supplies, dismantlement hand tools, and the subcontract (A5X) costs for dismantlement of decommissioning projects. The scope of this element includes, but is not limited to, activities such as: the stripout, removal and size reduction, if required, of miscellaneous process equipment, distributed systems (building lighting/power, heating, water, sewer, etc.), and isolation of the building/structure/etc. from the rest of the plant infrastructure. This element also includes the costs associated with packaging, pre-certification[3] and movement to the nearest RFETS designated pickup point; i.e., building loading dock, etc., of contaminated wastes/materials generated during the overall dismantlement effort. Any additional movement or treatment, storage and disposal (TSD) of contaminated (hazardous and/or radiological) materials, after they have been packaged and staged at the pickup point, for the types of hazardous and/or toxic wastes generated as a result of the overall dismantlement effort are not included in this element. These waste disposal costs are the sole responsibility of Waste Management (WM). For reporting purposes, the decommissioning costs of contaminated area gloveboxes, process piping/ductwork, internal tanks, etc. will be included under the dismantlement WBS element of that particular building or facility. In addition, the acquisition costs of decommissioning required waste containers, e.g., SWBs, will be included under this WBS element.

5.6 DEMOLITION AND DISPOSAL

As applicable, this element covers all the task specific direct labor, equipment, materials, supplies and subcontract (A5X) costs for the demolition and disposal of clean construction rubble and debris of decommissioning projects. The scope of this element includes, but is not limited to, activities such as the demolition and disposal of the roof, non-structural and structural components, floor slabs, foundations, connecting structures (tunnels, breezeways, overhead walkways, etc.) of the building/structure undergoing demolition. Additionally, for ease of access for future RFCA activities, this element could, (if applicable), include the excavation of surface contaminated soil, back filling, grading and revegetation, as appropriate. This element also includes the costs associated with packaging, pre-certification[4] and movement to the nearest RFETS designated pickup point; i.e., building loading dock, etc., of contaminated wastes/materials generated during the overall demolition and disposal effort. Any additional movement or treatment, storage and disposal (TSD) of contaminated (hazardous and/or radiological) materials, after they have been packaged and staged at the pickup point, for the types of hazardous and/or toxic wastes generated as a result of the overall demolition and disposal effort are not included in this element. These waste disposal costs are the sole responsibility of Waste Management (WM).

5.7 PROJECT MANAGEMENT

As applicable, this element covers all the task specific direct labor, equipment, materials, supplies and subcontract (A5X) costs for the project management of decommissioning projects. The scope of this element includes, but is not limited to, activities such as: project management, construction management, oversight, project engineering, project administration, project controls and reporting,

[3] Pre-certification of waste materials is defined as that degree or amount of waste inspection and certification required, on the part of the specific D&D Project, to ensure that there is a reasonable probability that the packaged wastes will not be returned to the project for additional work. Pre-certification does not involve the more sophisticated techniques of waste certification such as, NDA, headspace sampling, etc. These sophisticated certification techniques are the responsibility of Waste Management (WM).

[4] Pre-certification of waste materials is defined as that degree or amount of waste inspection and certification required, on the part of the specific D&D Project, to ensure that there is a reasonable probability that the packaged wastes will not be returned to the project for additional work. Pre-certification does not involve the more sophisticated techniques of waste certification such as, NDA, headspace sampling, etc. These sophisticated certification techniques are the responsibility of Waste Management (WM).

project finance and accounting, project-specific training coordination, project records management and document control, etc.

5.8 SUPPORT SERVICES

As applicable, this element addresses all the task specific direct labor, equipment, materials, supplies and subcontract (A5X) costs for support services for decommissioning projects. The scope of this element includes, but is not limited to, support services such as: training, procurement and contract administration, security and fire protection, QA/QC, waste inspection and certification, transportation and construction equipment, radiological operations and engineering, Radiation Control Technician (RCT) support coordination and management, medical and health, safety and industrial hygiene, shipping/receiving and warehousing, legal, regulatory interface, laundry, small tools and PPE, analytical laboratory, toxic and hazardous material handling, utilities, excess property, telecommunications and information resources, finance and administration, planning and integration, and other support services as yet to be identified. This element does not cover any RCT direct labor costs associated with the execution of the decommissioning WBS elements, e.g., Decontamination.

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SECTION 6.0
DESCRIPTION OF FACILITIES

6.1 FACILITY CLASSIFICATION

The Rocky Flats Environmental Technology Site (RFETS) is comprised of over 600 facilities ranging from trailers and small tanks to massive process buildings remaining to be decommissioned. The various ways in which these facilities are classified in the FDCM are presented in the Facility Classification Section below – see Exhibit 6.1. Additional details for each class of facility is presented in subsequent sections. Appendix A contains a complete list of the facilities addressed in this revision of the model.

6.1.1 Structure Type

RFETS facilities are classified by their type. There are six types of facilities/structures as follows:

- Buildings
- Trailers
- Cooling Towers
- Tents
- Tanks
- Infrastructure

The total area and number of facilities of each structure type included in the FDCM are shown in Table 6.1.

Table 6.1. RFETS Buildings/Facilities Classification and Area

CLASSIFICATION	NUMBER OF STRUCTURES	TOTAL AREA OF EACH CLASSIFICATION (SQ.FT.)
Buildings	218	2,756,173
Trailers	109	371,957
Cooling Towers	14	16,803
Tents	12	168,900
Infrastructure	Lot	NA
Total	**352**	**3,307,960**
External Tanks*	249	Volume 967,844 ft^3
Total No. Facilities	**601**	

*Internal tanks are addressed under the buildings in which they are located.

6.1.2 Contamination Levels

In accordance with the Rocky Flats Cleanup Agreement (RFCA), facilities are classified by their contamination levels into three types as follows:

- Type 1 (T1): Facilities/buildings free of contamination.

- Type 2 (T2): Buildings without significant contamination or hazardous substance contamination but that contain some radiological contamination or hazardous substance contamination. The extent of the contamination is such that routine methods of decontamination should suffice and only a moderate potential exists for environmental releases during decommissioning.

- Type 3 (T3): Facilities/buildings with significant contamination and/or hazards. Type 3 buildings contain extensive radiological contamination, usually as a result of plutonium processing operations or accidents.

Areas within some of the T2 buildings and all the T3 buildings have been further classified as contaminated (CA) or non-contaminated (non-CA) as discussed in Section 3, General Assumptions.

6.1.3 Building Construction

Buildings are grouped into four construction types as follows:

- Modular
- Masonry
- Reinforced Concrete
- Massive Reinforced Concrete

Some buildings have more than one type of construction. When this information is known, the building is classified either as the predominant construction type, or the building area is subdivided into the various construction types. Building 886 is an example where the building area is subdivided into different types of construction. The Type 2 area of Building 886 is reinforced concrete, and the 2CA area is massive reinforced concrete.

6.1.4 Asbestos Level

Buildings and trailers are classified as to whether or not they may contain asbestos as shown below. Asbestos may be found in older buildings in flooring materials, building insulation, pipe insulation, and construction materials such as transite panels.

- Buildings
    - Pre-1980 - Assumed to contain asbestos
    - 1980 or later - Assumed to contain no asbestos

- Trailers
    - Pre 1989 - Assumed to be contaminated
    - 1989 or later - Assumed to be uncontaminated

6.2 BUILDINGS

Currently, there are 218 buildings included in the FDCM. In addition to being classified by type of structure, buildings are further grouped by construction type, date of construction, and extent of contamination. The four construction types are modular, masonry, reinforced concrete, and massively reinforced concrete. The date of construction provides a benchmark for asbestos use during building construction. Buildings constructed prior to 1980 are assumed to contain asbestos insulation or construction materials containing asbestos; buildings constructed during or later than 1980 are assumed to contain no asbestos. Table 6.2 shows the total area of buildings with each type of construction broken down by contamination level type.

Table 6.2. Areas of Building Construction Types By Contamination Level Type

BUILDING CONSTRUCTION TYPE	CONTAMINATION LEVEL AREAS (sf.)					TOTAL AREA (sf.)
	TYPE 1 (T1)	TYPE 2 (T2)	TYPE 2CA (T2CA)	TYPE 3 (T3)	TYPE 3CA (T3CA)	
Modular	163,015	19,800	0	0	0	182,815
Masonry	440,065	753,707	241,829	107,699	62,511	1,605,811
Reinforced Concrete	25,925	36,516	60,934	521,520	298,062	942,957
Massive Concrete	0	21,040	3,550	0	0	24,590
Total	629,005	831,063	306,313	629,219	360,573	2,756,173

6.2.1 Building Process Systems

The FDCM also includes estimated decommissioning costs for special process systems and equipment contained within certain buildings. Decommissioning cost estimates for these process systems and equipment, which include gloveboxes, ductwork, piping, and internal tanks, are generated separately for the major process buildings on the site and are included under Dismantlement for these buildings in the FDCM. These buildings include all Type 3 buildings (Buildings 559, 777, 371, 707, 771, 776) and four Type 2 buildings (Buildings 444, 881, 886, and 991).

- **Gloveboxes**: There are 853 remaining gloveboxes included in the FDCM that must be decommissioned. The total volume of gloveboxes included in the FDCM is estimated to be 226,133 cubic feet. Appendix E provides additional information on gloveboxes.

- **Process Piping, Ductwork, and Internal Tanks (PD&T):** With the exception of Building 779, the FDCM-estimated direct decommissioning costs for piping and ductwork (including internal process related tanks) in the contaminated process areas of T3 buildings are based on an adjusted scaled function of the actual total direct PD&T costs for Building 779. It is assumed that there are direct functional relationships between a specific building's glovebox volume, internal tank volume, size of the building's contaminated area (CA), and its estimated PD&T decommissioning costs. The estimated direct piping decommissioning costs for a specific T3 building are scaled functions of that building's internal tank volume (in ft^3) and the size (in ft^2) of the building's CA compared to those same parameters of Building 779 and Building 779's actual piping decommissioning costs. For duct decommissioning costs, the building's glovebox volume (ft^3) and CA area (ft^2) are scaled to those like physical parameters for Building 779 and Building 779's actual duct decommissioning costs. The volume of piping (13,858 ft^3) and ducting (21,779 ft^3) in Building 779 are based on the most current available information. The derivation of the equations used to calculate the FDCM PD&T decommissioning costs is shown in Appendix G.

- The PD&T decommissioning costs for Building 779 are based on Actual Cost of Work Performed (ACWP) pricing information for Building 779 PD&T removal costs – see Appendix L.

- For the four selected T2 buildings (Buildings 444, 881, 886, and 991), the logic described above for T3 buildings for estimating PD&T decommissioning costs was used. In addition, a discounting factor was applied which adjusts the PD&T decommissioning costs of the T2 buildings down by the ratio of the difficulty factors of T2CA buildings to T3CA buildings (see Table 7-1). For the remaining T2 buildings and all T1 buildings, the PD&T decommissioning costs, as appropriate, are included in the specific building's Dismantlement unit costs.

- **Internal Building Tanks:** Internal building tanks are those tanks that are physically located within a building and are generally associated with processing operations. These tanks range in size and configuration from small diameter pencil tanks to large diameter process tanks. The contents of these tanks include such materials as compressed air, Argon, fire suppression water, nitrogen, propane, diesel fuel, and a wide variety of process and waste liquids. Within the seven T3 and the four selected T2 buildings, there is an estimated 61,622 ft^3 of internal process tank volume. Unlike the remaining building internal tanks, whose decommissioning costs are included in the building unit decommissioning costs, these T3 and designated T2 tanks require separate consideration. For Revision 3 of the FDCM, the extraordinary decommissioning costs for these internal tanks are included as part of the PD&T costs indicated above.

6.2.2 Building Slabs and Basements

- Decommissioning costs for buildings include the costs for demolition and disposal of building slabs, footings, foundations, basement walls and partitions, etc. as shown below.

- **Building Slabs:** Building slabs, footings, and foundations to a depth of three feet below grade level will be removed, size reduced, and disposed of as part of the building decommissioning. It is assumed that portions of building foundations three feet or more below grade will be left in place.

- **Buildings with Basements:** The grade level floor of buildings with basements will be removed. The basement exterior walls and basement partition walls will be removed to a depth of three feet below grade level. The size-reduced rubble from the building may possibly be included in the backfill to grade. This disposal mechanism will be assessed on a case-by-case basis during the planning and engineering for the building decommissioning.

- **Buildings Built into the Sides of Hills:** At least three multilevel buildings at RFETS (Buildings 371, 771, and 881) are built into the sides of hills with a portion of one or more levels of the buildings below grade. The portion of the buildings below grade will be treated as basements, i.e., all portions of the structure (exterior walls, footings, building floors, and interior partitions) will be removed to a depth of three feet below grade level. As with basements, sized-reduced rubble may possibly be used as backfill. This disposal mechanism will be assessed on a case-by-case basis during the planning and engineering for the building decommissioning.

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6.3 TRAILERS

Most of the 109 trailers at RFETS remaining to be decommissioned are used primarily for office space and are classified as T1 (no contamination); however, two trailers (T760A and T122A) have been identified as T2. Trailers are further classified into two groups: trailers installed before 1989 and trailers installed in 1989 or later. The decommissioning of trailers installed before 1989 is assumed to be more expensive because of poor records regarding their use and, because of the higher probability that they will have radiological contamination since production operations did not cease until 1989.

Because all trailers installed prior to 1989 are assumed to contain some contamination, they are similar to Type 2 facilities. Therefore, the FDCM handles the two Type 2 trailers as trailers installed prior to 1989.

Trailers at RFETS are located on asphalt pads. The decommissioning costs for the asphalt pads on which the trailers are located are not included in the trailer decommissioning costs.

6.4 COOLING TOWERS

There are 14 cooling towers on the RFETS site which are scheduled for decommissioning. These towers, all of which are classified as T1, cool service water used for various cooling purposes in many of the buildings throughout the site. Some of the cooling facilities are modular which means the cooling equipment is a unit which can be removed for salvage or disposed of during Deactivation. In the FDCM, this type of cooling tower will be referred to as a manufactured or prefabricated unit to eliminate any confusion with building modular construction. These cooling towers are mounted on concrete slabs or piers. The removal of these piers and slabs is a decommissioning responsibility.

Other cooling towers are structures with wood, fiberglass, or transite panels installed in a wood frame. These towers are usually mounted on concrete pedestals over reinforced concrete basins which are considered part of the tower facilities for decommissioning purposes. These frame cooling towers range from about 2,000 to 3,200 square feet in area and up to 37 feet in height and are referred to as constructed or assembled-on–site cooling towers.

6.5 TENTS

Twelve tents, which range in size from 9,000 ft^2 to 21,600 ft^2, remain on site and must be decommissioned. Eleven of these tents are classified as T2 facilities and serve as storage facilities for packaged low-level contaminated waste. These eleven tents are erected on large asphalt pads. The decommissioning costs for the pads under and around the tents are not included in the tent decommissioning costs. **WHERE ARE THEY?** The twelfth tent, classified as T1, is erected over river rock for drainage and contains pond water treatment equipment and materials. Three of the T2 tents contain Permacon enclosures (hard walled containment structures) which increase their decommissioning costs.

6.6 EXTERNAL TANKS

RFETS has over 251 tanks located outside of buildings remaining to be decommissioned. The primary use of these tanks is to store liquid fuels. External tanks are classified as either T1 tanks or T2 tanks. The current estimate on the total volume of external tanks is 917,941 cubic feet. This volume was determined using information from the RFETS Comprehensive Tank Report.

6.7 OTHER FACILITIES

Estimated costs to decommission other types of facilities at RFETS are included in the model. The other facilities included in the model at this time include:

- **Sanitary Sewage Plant:** A separate cost estimate for the decommissioning of the RFETS sewage plant, which consists of various buildings, trailers, tanks, drying beds, evaporators, and other structures, was developed. The buildings in the sewage plant are included in the buildings list in Appendix A; the estimated decommissioning costs for the other structures in the plant are included in the summary of total decommissioning costs in Section 9.

- **Underground Storage Vaults:** The four underground massive reinforced concrete storage vaults (Facilities 996, 997, 998, and 999) will be treated as massive concrete buildings in this revision of the FDCM.

- **Waste Pits:** Some processing and other buildings have separate waste pits associated with them. These pits, which may be partially imbedded in the ground, are treated as small Type 2 reinforced concrete structures in the FDCM.

- **Water Storage Ponds**: <u>Includes the decommissioning costs for removal and disposal of the water storage pond's ancillary hardware and piping with the following generic tasks: (Note the removal and disposal of the earthen dam structure is not included in this task)</u>

  - Removal and disposal of any associated concrete dam structures, e.g., spillway, walkways.

  - Removal and disposal of any associated dam piping, e.g., gate valves

  - Backfilling, grading, compaction, and revegetation, as required.

- **Miscellaneous Site Infrastructure**

  - **Railroad Spurs and Crossings:** Includes the decommissioning costs for removal and disposal of 4.86 miles of RFETS owned railroad spurs and crossings (tbd miles to be removed) with the following generic tasks:

    - Removal and disposal of all rail, ties, crossing guards, signs, and associated hardware, e.g., switches, frogs, plates.

    - Removal and disposal of all track ballast.

    - Backfilling, grading, compaction, and revegetation, as required.

  - **Perimeter and Security Fencing:** Includes the decommissioning costs for removal and disposal of the Site's approximately 44,700 ft. of perimeter (12,178 ft.) and security chain link fencing (32,540 ft.) with the following generic tasks:

    - Removal and disposal of fencing including fencing, poles (including bases), razor wire, signs, and all associated hardware.

    - Backfilling, grading, compaction, and revegetation, as required.

- **External Perimeter and Facility Lighting:** Includes the decommissioning costs for removal and disposal of the Site's external perimeter and facility lighting with the following generic tasks:

  - Removal and disposal of lighting and power poles (including bases), lighting fixtures, wire, road signs, and all associated hardware.

  - Backfilling, grading, compaction, and revegetation, as required.

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SECTION 7.0
RESOURCES AND COSTS

- The unit cost estimates and resources used in the FDCM originate from a variety of sources. To the extent possible, these estimates are based on completed or on-going Rocky Flats decommissioning or construction projects, e.g., 779 Cluster. When project cost information is not available, actual costs from other commercial and government projects are used; or, if no other information is available, detailed and conceptual engineering estimates are used. This section describes the basis and derivation of the unit cost estimates used in the model – see Tables 7.1 and 7.2. The tables in Appendix D contain the detailed unit cost estimates for each facility type. An example illustrating how the model can be used to calculate the decommissioning costs for a building is in Appendix M.

The decommissioning unit costs developed in this section do not include any of the time dependent potential cost saving initiatives presented in Appendix K for RSOPs (RFCA Standard Operating Protocols), PA Reduction, Dose Based Standards, Learning Curve, Centralized Waste Reduction facility, CWRF, etc. The cost impact of these initiatives are separately calculated and subtracted from the total decommissioning costs generated by the model to obtain an adjusted total cost.

Table 7.1. Adjusted FDCM Unit Costs for Pre-1980 Masonry Buildings Located Inside the PA Based on 788, 779, and RFETS Building Factors ($/sq.ft)

WBS	T1	T2	T2 CA	T3	T3 CA
Planning & Engineering	5.00	25.50	30.50	39.50	47.50
Characterization[1]	10.75	42.00[1]	50.50[1]	46.25	55.50
Site Prep	3.75	8.75	10.50	9.50	11.50
Decontamination	35.00	35.00	81.50	38.50	89.50
Dismantle	23.50	76.75	92.00	84.50	101.50
Demo/Disposal	20.00	20.00	20.00	20.00	20.00
PM	10.00	50.50	61.50	68.00	81.50
Support Services	13.50	72.00	86.50	90.00	108.00
Total Unit Cost	121.50	330.50	433.00	396.50	515.00
Support Cost	28.50	148.00	178.50	197.50	237.00
Work Cost	93.00	182.50	210.00	199.00	278.00
Support %	24	45	41	50	46
Work %	76	55	59	50	54

NOTE:

- See building factors page 30 FDCM Rev. 3 for CA multiplier.
- Above Unit Costs are rounded to nearest $0.25
- "Support" Cost is the sum of (P&E + PM + SS). "Work" Cost is the sum of the remaining WBS elements.
- T2 CA = 3.17/2.64 = 1.2 T3 CA = 3.48/2.90 = 1.2
  T2 T3
- [1]T2 Characterization @ $42.00/sq.ft x 1.2 = $50.50/sq.ft for T2 CA

Table 7.2. Adjusted FDCM Unit Costs for Pre-1980 Masonry Buildings Located Outside the PA Based on 788, 779, and RFETS Building Factors ($/sq.ft)

WBS	T1	T2	T2 CA
Planning & Engineering	5.00	25.50	30.50
Characterization[1]	8.50	33.50[1]	40.00[1]
Site Prep	3.00	7.00	8.50
Decontamination	31.00	31.00	73.00
Dismantle	15.00	61.00	73.00
Demo/Disposal	15.50	15.50	15.50
PM	10.00	50.50	61.50
Support Services	13.50	72.00	86.50
Total Unit Cost	101.50	296.00	388.50
Support Cost	28.50	148.00	178.50
Work Cost	73.00	148.00	210.00
Support %	28	50	46
Work %	72	50	54

NOTE:

- See building factors page 30 FDCM Rev. 3 for CA multiplier.
- Above Unit Costs are rounded to nearest $0.25
- "Support" Cost is the sum of (P&E + PM + SS). "Work" Cost is the sum of the remaining WBS elements.
- $\frac{\text{T2 CA}}{\text{T2}} = 3.17/2.64 = 1.2$ $\frac{\text{T3 CA}}{\text{T3}} = 3.48/2.90 = 1.2$
- [1]T2 Characterization @ $33.50/sq.ft x 1.2 = $40.00/sq.ft for T2 CA

7.1 BUILDINGS

This section describes the basis and derivation of unit costs for decommissioning buildings at RFETS. Decommissioning costs for buildings have been separated into the eight elements or activities in accordance with the decommissioning WBS. In addition, a distinction has been made to differentiate between the T1 and T2 buildings located inside the PA as opposed to those located outside the PA.. A description of the unit cost derivation used for each building type is included under each element. Although there are numerous and relevant sources of recent RFETS decommissioning costs (see Section 2, Model Overview), the most viable and widely used cost information used in the model was the life cycle ACWP data from decommissioning Building 123, 207 cluster (B788), and the ACWP/EAC decommissioning cost data from the 779 cluster. Building 123 was a pre-1980 T2 masonry building whereas the 779 cluster was the first T3 building/cluster with associated T1 and T2 support facilities decommissioned at RFETS. As a general rule, the unit costs for four of the five "Work" WBS elements are 20% higher for work in the CA when compared to the unit costs for non-CA work tasks in like type buildings. The only exception to this rule is associated with *Demolition and Disposal* – see Appendix D. Other facility information including historical construction costs and building difficulty factors as well as best engineering judgment was also considered in the development of the unit costs.

7.1.1 Planning and Engineering

Planning and Engineering (P&E) unit costs are based upon a fraction of the total cost of a project and are therefore directly related to the complexity, location, and scope of the task. *P&E* fractions of the total building unit cost in the FDCM are shown in Table 7.2. It is assumed that *P&E* unit costs do not change with buildings of different construction types. In the FDCM, the base *P&E* estimating unit for all building types was originally derived from a pre-1980 T2 masonry building

(123) and adjusted based on 788 and 779 ACWP – see Appendix D. Contaminated Area *P&E* unit costs for buildings of like type are typically assumed to be about 20% higher than the *P&E* unit costs in the non-contaminated area of the same type building. Therefore, the *Planning and Engineering* fractions shown in Table 7.3 for masonry buildings can be used to estimate the *Planning and Engineering* unit costs for buildings of all contamination levels and construction types.

Table 7.3. P&E Unit Cost Factors of Total Decommissioning Unit Cost

Bldg. Type	P&E (%)	P&E (%) PA
T1	5	4
T2	10	8
T2 CA	9	7
T3	NA	10
T3 CA	NA	9

7.1.2 Characterization

The effort needed to characterize a building is directly proportional to the complexity of the building structure and the quantity of contaminants contained in the building. The more contaminants, the higher the contaminant concentration levels, and the more fixtures to survey, the higher will be the cost of characterization. This complexity directly relates to the cost of dismantlement; therefore, the cost to characterize a building is directly related to the cost for dismantlement regardless of the type of building. Based on the current available cost information, *Characterization* unit costs are assumed to be 55% of the *Dismantlement* unit costs for like T3 and T2 buildings. For T1 buildings/facilities, *Characterization* unit costs are assumed to be 57% of *Dismantlement* unit costs for T1 buildings. In the FDCM, the base Characterization estimating unit for all building types was originally derived from a pre-1980 T2 masonry building (123) and adjusted based on 788 and 779 ACWP – see Appendix D. Therefore, the *Characterization* fractions described above for masonry buildings can be used to estimate the *Characterization* unit costs for buildings of all contamination levels and construction types.

The complexity of decommissioning increases from Type 1 to Type 2 to Type 3 buildings and from uncontaminated to contaminated areas in buildings, but does not vary for buildings of different construction materials. The increased cost for dismantlement captures this increase in complexity. Because the cost for characterization is directly proportional to the cost of dismantlement, the characterization fractions described above for masonry buildings can be used to estimate the characterization costs for buildings of all contamination levels and construction types.

7.1.3 Site Preparation

Site Preparation unit costs are based upon a fraction of the total cost of a project and are therefore directly related to the complexity and scope of the task. Based on the current available cost information, *Site Preparation* unit costs are assumed to be 2% of the total decommissioning unit costs for like T3 and T2 buildings. For T1 buildings/facilities, *Site Preparation* unit costs are assumed to be about 3% of total decommissioning unit costs for T1 buildings. In the FDCM, the base *Site Preparation* estimating unit for all building types was originally derived from a pre-1980 T2 masonry building (123) and adjusted based on 788 and 779 ACWP – see Appendix D. Therefore, the *Site Preparation* fractions described above for masonry buildings can be used to estimate the *Site Preparation* unit costs for buildings of all contamination levels and construction types.

7.1.4 Decontamination

The cost to decontaminate buildings is based upon the types and levels of contamination present in the building. The categories of contamination include Toxic Substance Control Act (TSCA) (asbestos and PCB's), hazardous, and radioactive. The estimated decontamination unit costs generated in this section are costs per square foot of building area even though portions of interior building surfaces may not have to be decontaminated. Decontamination unit costs have been adjusted to cover a reasonable portion of all interior surfaces.

Buildings constructed before 1980 are assumed to contain asbestos; buildings constructed in 1980 or later are assumed to contain no asbestos. For buildings containing asbestos, the methodology described below to develop unit costs for decontamination is used.

Because T1 buildings are classified as radiologically clean, decontamination for T1 buildings includes decontamination only for hazardous and TSCA materials. The asbestos removal subcontract unit costs for both Building 889 and Building 123 were approximately $\$36.00/ft^2$. The adjusted costs for the decontamination of Building 123 was determined to be $\$31.00/ft^2$ (see Appendix C). These values include the cost for remediating any lead contamination that may be present. Both buildings were T2 buildings.

The conditions for conducting asbestos decontamination in T1 buildings are the same as for T2 buildings. Therefore, $\$31.00/ft^2$ is also used for asbestos decontamination of T1 buildings.

To derive the decontamination costs for a T3 building, building factors (see discussion in Section 7.1.5.1, Dismantlement of Building Structure) were used to account for work differences between a T2 and a T3 building. The calculation is:

$$\$31.00/ft^2 \ (2.90/2.64) = \$34.00/ft^2$$

Because T2CA and T3CA buildings also have significant radiological contamination, the scope for decontamination of these buildings is greater; hence, the cost to conduct the decontamination is higher. The ICF Kaiser report on Concrete Disposition dated 14 August 1998 indicates that average radiological decontamination costs for radiological decontamination of concrete surfaces are $\$30.00/ft^2$; therefore, the unit cost to decontaminate T2CA and T3CA buildings is:

For T2CA buildings: $(31+30)x1.2 = \$73.00/ft^2$

For T3CA buildings: $[34+(30x1.1)]x1.2 = \$80.50/ft^2$

If a building was built after 1979, it is assumed that it does not contain asbestos; however, a nominal allowance of $\$2.00/ft^2$ is included for these buildings, primarily for survey requirements to verify that other contaminants, such as lead, are not present.

7.1.5 Dismantlement

7.1.5.1 Dismantlement of Building Structure

Dismantlement costs for all building types are based on the actual adjusted dismantlement costs from the dismantlement of Building 123, a Type 2 masonry building and the 779 Cluster -see Appendix C.

To scale those costs to the other building types, a building difficulty evaluation was conducted (See Appendix B). This detailed evaluation considers several areas of work constraints and assesses the cost impact to the work scope. The ratio of these factors was then multiplied by the actual cost for the T2 building unit cost to develop the corresponding unit costs for the other building costs. For example, the T1 building cost was developed as follows:

Type 1 Building Factor – 1.06

Type 2 Building Factor – 2.64

Type 1 to Type 2 Ratio 1.06/2.64 = 0.4015

0.4015 x $61/ft^2 = $24.50/ ft^2 for dismantlement of a T1 building

Similar calculations were conducted for the building of other contamination types using their respective building difficulty factors to derive their dismantlement unit costs. The results of these calculations are shown in Table 7.4.

Table 7.4. Building Factors and Ratios for Different Types of Buildings

Building Type	T1	T2	T2CA	T3	T3CA
Factor	1.06	2.64	3.17	2.90	3.48
Ratio	0.4015	1.0000	1.2008	1.0985	1.3181

The change in the ratios from the T2 factor is consistent with the working restraints. TI buildings have no access restrictions and no restrictions due to radiological contaminants. T2 buildings have added access restrictions due to higher contaminants in other parts of the facility as well as some security requirements. T2CA rooms have significant access and work restrictions due to contaminants. T3 buildings have significant access restrictions due to the security requirements when compared to a T2 building. The worst case scenario is encountered in T3CA areas. These facilities have the strictest access restrictions due to security and the highest levels of contamination.

It is assumed that Dismantlement unit costs are the same for buildings of the same contamination type but of different construction materials.

A T1 facility was analyzed one-step further. T1 facilities contain no mission or vital safety system equipment (HEPA ventilation, hoods, etc.); therefore, the scope of work for dismantlement in a T1 building is less than for the other types of buildings. The building factors take into account only the difficulty due to the access to the work, not a change in scope. This decrease in the scope of work was estimated by assuming that these mission systems were equivalent to 40% of the dismantlement scope; hence, the new T1 dismantlement cost is:

$24.50/ft^2 X 0.6 = $14.50/ft^2

7.1.5.2 Dismantlement of Glove Boxes

<u>Glove box unit costs of $929/ ft^3 are based on the actual decommissioning costs from the glove box removal activities in Building 779. A primary assumption of the FDCM is that, until additional cost information is available from other glovebox decommissioning efforts, the 779 data will be the bench mark for estimating all Site glovebox decommissioning costs – see Appendix L. Appendix E contains details on the parameters used for calculating the Site's glovebox decommissioning costs. All glovebox</u>

decommissioning costs for a specific building are collected and displayed in the building's Dismantlement WBS element

7.1.5.3 Dismantlement of Piping, Ducting, and Internal Tanks

The estimated costs for the decommissioning of the piping, ducting, and internal process tanks (PD&T) are based on actual cost data from Building 779. A primary assumption of the FDCM is that, until additional cost information and/or planning information is available from other T3 buildings, the PD&T costs for Building 779 will serve as the bench mark for estimating the PD&T costs for all T3 buildings and four selected T2 buildings. Based on actual cost information from the recently completed decommissioning efforts in Building 779, the average PD&T decommissioning direct unit cost is $90/ft^3 of the building's assumed pipe, internal tank, and duct volume for all T3 buildings. For the selected T2 buildings, the T3 PD&T average direct decommissioning unit cost will be discounted by the T2/T3 ratio of building difficulty factors (see Table 7.3) and therefore equals $82/ft^3. All PD&T decommissioning costs for a specific building are collected and displayed in the building's Dismantlement WBS element.

7.1.5.4 Dismantlement of External Tanks

The estimated decommissioning costs for external tanks are based on actual cost data from the decommissioning of two fuel oil tanks, Tanks 221 and 224, and two acid tanks, Tanks 218-1 and 218-2. A linear equation was derived for estimating decommissioning costs of tanks larger than 1,500 cubic feet, and an exponential formula for tanks with a volume of 1,500 cubic feet or less (see Section 7.6)

7.1.6 Demolition and Disposal

The unit costs used to estimate the demolition and disposal costs for a facility are based upon the assumption that the building is clean (i.e., no remaining radiological, hazardous or TSCA contamination). The unit costs also include an allowance of $4.50/ft^2 for the transportation to and disposal of the clean debris at an approved sanitary landfill. On-grade slab and below grade, to a depth of three feet, slab and foundation removal costs are also included in the demolition and disposal costs. Additional information concerning building slabs and footings can be found in Section 7.2 below.

The building demolition and disposal costs were developed from the actual adjusted demolition and disposal cost for Building 123, a Type 2 building of masonry construction and 779, a Type 3 building. This adjusted cost was determined to be $15.50/ft^2 ($11.00/ft^2 for demolition and $4.50/ft^2 for transportation and sanitary landfill disposal). See Appendix C for additional information. The Building 123 cost was extrapolated utilizing building difficulty factors, subject matter expert (SME) input, ECHOS (1996) data, and the Delphi Process to include the T2 buildings constructed of other materials (reinforced concrete and modular). Because it is assumed that all buildings at RFETS will be clean at the commencement of demolition, the same demolition and disposal costs are applied to T1 and T3 buildings.

The unit costs for Demolition and Disposal of modular, reinforced concrete, and massive reinforced concrete buildings are derived by extrapolating the masonry building unit costs to buildings constructed of these other materials. The data was obtained from the ECHOS (1996) which delineates unit costs for different materials.

ECHOS specifies that the unit cost for demolition of a masonry wall is $0.94/ft^2, and the unit costs for demolition of modular and reinforced concrete buildings are $0.59/ft^2 and $3.44/ft^2 respectively. The cost for reinforced concrete demolition from ECHOS was for 12-inch thick concrete. Because the walls at RFETS are mostly 8 inches thick, the unit cost for demolition of reinforced concrete buildings was reduced by 1/3 to $2.30/ft^2. This information was then used to create ratios:

Ratio for Modular Buildings = 0.59/0.94 = 0.63

Ratio for Reinforced Concrete Buildings = 2.30/0.94 = 2.45

Using these factors and the actual unit cost for demolition and disposal of masonry buildings of $\$11/ft^2$ from B123, the unit costs for demolition of modular and reinforced concrete buildings are

Modular Buildings: 0.63 X 11 = $\$7.00/ft^2$

Reinforced Concrete Buildings: 2.45 X \$11 = $\$26.00/ft^2$ ($\$25.00/ft^2$ was used)

Obtaining a basis for the demolition of massive concrete buildings was more difficult. Very little information could be found dealing with demolition of this type of building. Therefore, best engineering judgment was employed to develop an estimate for the unit cost of demolition of massive concrete buildings. It was assumed that the unit cost for demolition of massive concrete buildings is 60 percent greater than the unit cost for reinforced concrete; therefore, the demolition unit cost for Massive Concrete buildings is $\$40.00/ft^2$. To date only a portion of one building, Building 886, with an area of 3,550 square feet and four underground storage vaults have been identified as having massive reinforced concrete construction.

Contained in the DOE Decommissioning Benchmark Study is an example supporting the massive concrete building demolition and disposal unit cost derived in the previous paragraph. This example presents the decommissioning costs for a representative research reactor which is a massive concrete structure. In the Decommissioning Benchmark study, the cost of concrete removal (demolition and disposal) for the reactor is \$869,330 for 180,920 ft^3 of concrete. This is a unit cost of $\$4.81/ft^3$.

The massive portion of Building 886 is 3550 ft^2. Using the unfactored demolition and disposal unit cost for massive concrete buildings of $\$44.50/ft^2$, the demolition and disposal cost for the concrete portion of B886 is:

$$\$44.50/ft^2 \times 3550\ ft^2 = \$157,975$$

RFETS Engineering records show that Building 886 is comprised of 34,666 ft^3 of concrete, and so the demolition and disposal cost/ft^3 is:

$$\$157,975/34,666\ ft^3 = \$4.56/ft^3$$

an amount very close to the $\$4.81/ft^3$ concrete removal cost in the DOE study.

Demolition and disposal unit cost estimates for buildings with basements or below-grade levels are the same as for buildings with multiple above-grade levels. The factors used to take into account multiple level buildings are presented in the Economies of Scale Section below. It is assumed that the added difficulty to remove the on-grade floor and basement walls and interior basement partitions to a depth of three feet below grade level is equivalent to completely removing the basement walls. Similarly, no factors to adjust the demolition and disposal unit cost were applied to buildings with levels partially buried in the sides of hills.

7.1.7 Project Management

Project Management (PM) unit costs are derived from historical cost data from 23 previous construction projects at RFETS and from the 123, 788, and 779 building/cluster decommissioning projects. The construction project data was retrieved from 1997 historical year end actual cost data for 23 capital construction projects performed and/or completed in 1997. All of the referenced construction projects occurred in non-CA areas and covered the same three building types. The *PM* construction project ratios to total unit cost were adjusted, as appropriate, based on additional actual cost data from the three decommissioning projects cited above to derive the building *PM* unit cost factors for decommissioning – see Table 7.5. Generally speaking, the *PM* unit costs for CA work varies between 20% to 22% higher than for non-CA *Project Management* for the T3 and T2 buildings. Therefore, the *PM* fractions described in Table 7.5 for masonry buildings can be used to estimate the *PM* unit costs for buildings of all contamination levels and construction types. In the FDCM, the base *PM* estimating unit for all building types was originally derived from a pre-1980 T2 masonry building (123) and adjusted based on 788 and 779 ACWP – see Appendix D.

Table 7.5. PM Unit Cost Factors of Total Decommissioning Unit Cost

Bldg. Type	PM/CM (%)	PM/CM (%) PA
T1	10	8
T2	17	15
T2 CA	16	14
T3	NA	18
T3 CA	NA	16

7.1.8 Support Services

Support Services unit costs are based upon a fraction of the total cost of a project and are therefore directly related to the complexity and scope of the task. Based on the current available cost information, *Support Services* fractions of the building unit costs are shown in Table 7.6. In the FDCM, the base *Support Services* estimating unit for all building types was originally derived from a pre-1980 T2 masonry building (123) and adjusted based on 788 and 779 ACWP – see Appendix D. Therefore, the *Support Services* fractions described in Table 7.6 for masonry buildings can be used to estimate the *Support Services* unit costs for buildings of all contamination levels and construction types.

Table 7.6. Support Services (SS) Unit Cost Factors of Total Decommissioning Unit Cost

Bldg. Type	SS (%)	SS (%) PA
T1	13	11
T2	24	22
T2 CA	22	20
T3	NA	24
T3 CA	NA	21

7.2 BUILDING SLABS AND FOOTINGS

- Decommissioning unit cost for removal of building slabs, footings, and foundations are generated independently from the building decommissioning unit costs so the two can be separated. The slab, footing, and foundation removal unit costs are combined into one unit cost for simplicity by converting the footing and foundation decommissioning unit cost (in vertical ft^2) to an equivalent unit cost based on the footprint area of the building and combining it with the slab removal unit cost. As shown in Table 7.7, this unit cost includes a nominal amount for any additional characterization and decontamination of the slab, footing, and/or foundation that may be required and for additional dismantlement of pipes, conduits, or other items that may surface during slab removal. It also covers the decommissioning of lines leading to valve vaults within five feet of the slab and the valve vault if it is not actively connected to any other building.

- The unit removal cost estimation data from Richardson Engineering Services, Inc. (1995), corrected for escalation and expressed in constant fiscal year 2000 dollars, for a six inch thick rod reinforced Portland Cement (PC) concrete pavement is approximately $\$2.00/ft^2$. To this, $\$4.50/ft^2$ is added for rubble disposal at a sanitary landfill giving a total unit cost for Demolition and Disposal of a building slab of $\$6.50/ft^2$. Nominal unit costs for the other decommissioning activities are added except for Site Preparation and Dismantlement which are not applicable for slab removal. A unit cost based on building footprint area for footing and foundation removal to a depth of three feet below grade based on the cost for footing and foundation removal for a nominal 10,000 square foot building was generated to provide one unit cost for slab, footing, and foundation removal. These estimates for on-grade and below grade slab and associated foundation removal are summarized in Table 7.7. For simplicity, in the building unit cost tables in Appendix D, the footing/foundation removal costs are included as a line item in the Demolition and Disposal unit costs.

- Table 7.7. Summary of Concrete Building Slab, Footing, and Foundation Removal Unit Costs

	UNIT COSTS ($\$/ft^2$)		
DECOMMISSIONING ACTIVITY	TYPE 1	TYPE 2	TYPE 3
PLANNING AND ENGINEERING	.40	1.25	2.00
CHARACTERIZATION	.50	2.00	2.00
SITE PREPARATION	N/A	N/A	N/A
DECONTAMINATION	.50	1.00	2.00
DISMANTLEMENT	N/A	N/A	N/A
DEMOLITION AND DISPOSAL	7.50	7.50	11.50
PROJECT MANAGEMENT	1.00	3.00	4.25
SUPPORT SERVICES	.60	1.00	1.75
SUBTOTAL	**10.50**	**15.75**	**23.50**
FOOTING/FOUNDATION	2.15	2.50	3.25
BACKFILL AND COMPACTION	2.00	2.00	2.00
TOTAL	**14.65**	**20.25**	**28.75**

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7.3 TRAILERS

Most trailers at RFETS are used as administrative/office areas and are therefore classified as Type 1; however, there are two Type 2 trailers (T760A and T122A) that may have been exposed to contamination. Trailers are also categorized into two groups, trailers installed before 1989 or trailers installed in 1989 or later. Operations ceased at RFETS in 1989; therefore, it is assumed that trailers installed in 1989 or later will have no external or internal surface contamination due to site operations and will require a less rigorous facility disposition process.

Decommissioning costs for trailers installed before 1989 were estimated using an adjusted, unescalated actual unit cost of $\$62.50/ft^2$ derived from the decommissioning of the 690T Cluster trailers in 1996. The trailer decommissioning subcontractor performed the Site Preparation, Decontamination, Dismantlement, and Demolition & Disposal tasks. The adjusted subcontract unit costs for these four activities was calculated to be $\$43/ft^2$. The unit costs for Planning and Engineering, Support Services, Characterization, and Project Management must be added to the $\$43/ft^2$ to obtain the total decommissioning unit cost of $\$$*62.50*$/ft^2$. Because these trailers were T1 facilities, Planning and Engineering and Project Management factors of 5 percent (as explained above) and 10 percent (derived for T1 building decommissioning) respectively were used to estimate these activities for trailers.

Characterization and Support Services costs were estimated using a ratio of the activity cost to the total cost for T1 masonry buildings. The calculation was performed as follows:

T1 Masonry Building Characterization Unit Cost – $8.50/ft^2

T1 Masonry Building Support Services Unit Cost - $13.50/ft^2

T1 Masonry Building Total Unit Cost – $101.50/ft^2

Characterization costs = 8.50/101.50 or 8% of the total project unit cost

Support Services costs = 13.50/101.5.5 or 13% of the total the project unit cost

There was no actual data for decommissioning a trailer installed in 1989 or later; therefore building factors were used to obtain the total cost. A pre 1989 trailer is similar to a T2 building with no contaminated area, and a 1989 or later trailer is a T1 facility. The building factors between a T1 (1.06) and a T2 (2.64) derived in Section 7.1.5.1 were used to determine the subcontract decommissioning unit costs for 1989 and later trailers. The other activity costs for decommissioning 1989 or later trailers were derived using the same percentages noted above. The percentages and unit costs for decommissioning of trailers are summarized in Table 7.8 below.

Table 7.8. Summary of Trailer Unit Costs

DECOMMISSIONING ACTIVITY	PERCENT OF TOTAL UNIT COST	PRE-1989 UNIT COST ($/FT^2)	1989 OR LATER UNIT COST ($/FT^2)
Planning and Engineering	5	3.50	1.50
Characterization	8	5.50	2.00
Site Preparation	(1)	(1)	(1)
Decontamination	(1)	(1)	(1)
Dismantlement	(1)	(1)	(1)
Demolition and Disposal	64	(2) 43.00	17.50
Project Management	10	6.50	2.50
Support Services	13	8.50	3.50
Total	100	67.00	27.00

(1) Included in Demolition and Disposal unit cost

(2) Actual adjusted cost from decommissioning of 690T Cluster trailers

The cost to remove the asphaltic concrete pads on which the trailers are installed are not included in the cost model. These pad areas under the trailers and outside of the trailer footprint areas (i.e., parking areas) are not included in the overall FDCM-Based Decommissioning Cost Estimate. The removal of these pad areas will be accomplished under the auspices of Environmental Restoration.

7.4 COOLING TOWERS

There are two types of cooling towers, manufactured or prefabricated, and cooling towers constructed or assembled on site. Prefabricated cooling towers are delivered to the site either completely or almost completely assembled and after placement and hookup to the system and the proper support utilities (electrical, water supply etc.) are ready for use. Constructed or assembled-on-site cooling towers are normally wooden frame structures with associated wood, fiberglass or transite panels usually constructed over a reinforced concrete basin. The manufactured or pre-fabricated units are normally used to take care of the smaller needs for service cooling circulating water while the constructed or assembled-on-site units are used to provide service water for larger equipment cooling needs.

It is assumed that the prefabricated cooling units will be removed for salvage during Deactivation leaving only the concrete slab or piers to be decommissioned. The decommissioning cost will be the same as for the removal of a Type 1 concrete slab which is $10.50/ft^2.

There are three components to the decommissioning costs of constructed or assembled-on-site cooling towers, the frame structure, the basin base or slab, and the walls of the basin. The concrete pedestals will be removed with the basin walls. The frame structure, although it is at an elevated height, is similar to a Type 1 modular building with some differences because of its simple structure. The towers with transite panels (which contain asbestos) have higher decontamination costs than towers with wood or fiberglass panels. Estimates for the frame cooling tower decommissioning unit costs are summarized in Table 7.8. The basin removal unit cost is assumed to be the same as for the removal of a Type 2 building concrete slab, footing, and foundation.

Table 7.8. Constructed Cooling Tower Unit

Decommissioning Activities	Unit Costs In \$/FT^2 of Basin Area		
	Wood or Fiberglass	Transite	Basin
PLANNING AND ENGINEERING	5.00	5.00	1.25
CHARACTERIZATION	3.00	3.00	2.00
SITE PREPARATION	3.00	3.00	N/A
DECONTAMINATION	2.00	15.50	1.00
DISMANTLEMENT	15.00	15.00	N/A
DEMOLITION AND DISPOSAL	7.00	5.00	10.00
PROJECT MANAGEMENT	10.50	10.50	3.00
SUPPORT SERVICES	7.00	7.00	1.00
BACKFILL AND COMPACTION	N/A	N/A	2.00
SUBTOTAL	52.50	64.00	20.25
CONCRETE BASIN	20.25	20.25	N/A
TOTAL	72.75	84.25	N/A

7.5 TENTS

The majority of flexible panel/rigid frame structures, commonly know as tents, were erected at RFETS prior to 1989 and were used for radiologically contaminated waste storage and processing. As a result of this use, both the internal and external surfaces of tents may be contaminated; hence, tents are assumed to be T2 facilities. They are further categorized into those tents which contain Permacon enclosures and those without Permacon enclosures. The estimated decommissioning costs for tents are based on adjusted values contained in an estimate developed in August 1998 for four tents in the 904/906 cluster. It is anticipated that all tent decommissioning tasks will be subcontracted except Planning and Engineering, Project Management, and Support Services. Although the unit costs for those tents without Permacon enclosures are lower than those with Permacon enclosures ($8.50/ft^2 vs. $9.50 /ft^2), it is assumed that the unit costs for the tasks that will not be subcontracted will be the same in both cases (rounded up to the nearest dollar). The non-subcontracted costs were developed using the factors for a Type 2 building – see Appendix D.

The asphalt pads under the tent and outside of the tent footprint area are not included in the FDCM decommissioning cost estimate. The costs for the removal of these pad areas will be borne by Environmental Restoration.

For the purposes of this estimate, it has been assumed that the decommissioning of the tents will be conducted in blocks of four units at a time. The Planning and Engineering unit cost is based on that premise and, will be constant in both cases. The factors used are shown in Table 7.9.

Table 7.9. Tent Decommissioning Factors

Type	Planning & Engineering	Characterization	Project Management	Support Services
2	3%	16%	13%	13%

7.6 EXTERNAL TANKS

The cost estimates for decommissioning external tanks (tanks located outside of buildings) were developed using the unescalated actual costs to decommission two large fuel tanks, Tanks 221 and 224, and two small acid tanks, Tanks 218-1 and 218-2. The two fuel tanks, with a total volume of 2,750,000 gallons, were decommissioned in 1996. The volume of Tank 221 was 128,680 ft^3, and the volume of Tank 224 was 110,585 ft^3. The total cost of the decommissioning was \$445,000. Acid tanks 218-1 and 218-2 both had a volume of 10,905 gallons, and the cost to decommission both acid tanks was \$23,000. Using the above data, two equations were developed to estimate decommissioning costs for external tanks.

For tanks with volumes greater than 1,500 ft^3, the equation is:

$$\text{Estimated Decommissioning Cost in} = 1.787 \text{ X Tank Vol. in } ft^3 + \$8,782$$

For tanks with volumes equal to or less than 1,500 ft^3, the equation is:

$$\text{Estimated Decommissioning Cost} = (\text{K Vol.})^{0.456} \text{ X } \$9,673.6$$

Additional details on the decommissioning cost estimates for external tanks can be found in Appendix F.

7.7 OTHER FACILITIES

- **Sewage Treatment Plant:** A cost estimate for the decommissioning of the RFETS Sewage Treatment Plant (STP), which consists of various buildings, trailers, tanks, drying beds, evaporators, and other structures, was developed. The cost to decommission sludge drying beds and influent and effluent tanks in the sewage plant for the FDCM was calculated using the T2 slab with foundation unit costs. For above the above-grade concrete tank walls, a cost of \$18.00 or \$20.25 per vsf. (vertical square foot) was used for T1 or T2 facilities, respectively. Building decommissioning unit costs are used to estimate the costs for the removal of structures over sludge drying beds or enclosing tanks and equipment. The STP estimate is included in the total site decommissioning costs presented in Section 9.

- **Underground Storage Vaults:** The decommissioning unit costs for the four underground massive reinforced concrete storage vaults (Facilities 996, 997, 998, and 999) are assumed to be the same as for the decommissioning unit costs for Type 2 massive concrete buildings. They are included in Appendix A in the buildings list

- **Waste Pits:** The cost estimate for the decommissioning of the waste pits associated with several of the process buildings are based upon the unit costs for T-2 reinforced concrete buildings. Waste pits are included in Appendix A under buildings

- **Water Storage Ponds**: Unit cost templates were developed to estimate the total direct cost to decommission the ***tbd*** RFETS water storage pond's ancillary hardware and piping – see Appendix D. The decommissioning costs for these items includes any required backfilling, grading, compaction, and revegetation. Overall, the unit costs to decommission the aforementioned water storage pond hardware and piping is estimated to be $/pond or a total direct cost of $***tbd*** for the tbd ponds.

- **Miscellaneous Site Infrastructure**

    - **Railroad Spurs and Crossings:** Unit cost templates were developed to estimate the total direct cost to decommission the 4.86 miles of RFETS owned railroad spurs and crossings – see Appendix D. The decommissioning costs for these items includes required backfilling, grading, compaction, and revegetation. Overall, the unit costs to decommission the Site's railroad track is estimated to be $***tbd****/ft* of length or a total direct cost of $***tbd****.*

    - **Perimeter and Security Fencing:** Unit cost templates were developed to estimate the total direct cost to decommission the 44,700 ft. of RFETS perimeter and security fencing - see Appendix D.. The decommissioning costs for these items includes required backfilling, grading, compaction, and revegetation. Overall, the unit costs to decommission the Site's perimeter and security fencing is estimated to be $***tbd****/ft* of length or a total direct cost of $***tbd****.*

    - **External Perimeter and Facility Lighting:** Unit cost templates were developed to estimate the total direct cost to decommission the approximate 316 RFETS external perimeter and facility lighting poles and fixtures – see Appendix D. The decommissioning costs for these items includes required backfilling, grading, compaction, and revegetation. Overall, the unit costs to decommission the Site's perimeter and facility lighting is estimated to be $***tbd****/unit* or a total direct cost of $***tbd****.*

7.8 ECONOMIES OF SCALE

When a second floor is added to a building or a building has below grade levels, the decommissioning costs do not increase proportionally. The wiring and ductwork frequently service more than one floor. Additionally, decommissioning work can frequently use infrastructure established for one floor to support the decommissioning of the upper floor(s). The model employs an exponential equation to estimate the reduction in cost for buildings with multiple levels. The equation calculates an adjustment factor for each element of the building model, as follows:

$$\text{Cost} = \left(\frac{\text{Total Area}}{\text{Footprint}}\right)^{\text{Exponent}} \text{ x Footprint x Unit Cost}$$

where Total Area is the total area of all building levels, and Footprint is the area enclosed by the building foundation.

Exponents of 1 (Demolition and Disposal); .85 (Decontamination, Site Preparation, and Dismantlement); 0.7 (Support Services); and 0.2 (Project Management, Planning and Engineering, and Characterization) were used to relate costs to the effective area based on the building footprint and the total building area.

The exponent of 1 (Demolition and Disposal) assumes there is no economy of scale. Essentially, the volume of rubble is assumed to be the same for a second story area as for the ground floor area.

The exponent of 0.85 (Decontamination, Site Preparation, and Dismantlement) applies were an economy of scale exists, but with only slight reduction in cost.

The exponent of 0.7 (Support Services) applies were an economy of scale exists with a moderate reduction in cost (approximately a 38% reduction for a second floor with the same area as the ground floor).

The exponent of .2 (Project Management, Planning and Engineering, and Characterization) applies were an economy of scale exists with a significant reduction in cost (approximately an 85% reduction). This exponent is used for those factors that do not vary significantly from project to project and depend less on the total building area.

7.9 BENCHMARKING

Direct cost comparisons between Rocky Flats and other sites are very difficult and potentially deceptive and often cannot be accurately accomplished. Many complications are encountered when attempting to normalize the decommissioning costs so that an "apples-to-apples" comparison can be made. From an accounting perspective, the costs must be adjusted for organization and content of work scope, contracting strategy, escalation, various levels of burdens and overhead, overtime, work stoppages, and other unexpected or unforeseen conditions. Technically, comparable scopes need to be benchmarked. From an execution perspective, costs can vary substantially due to contracting approach, health and safety requirements, environmental requirements and regulations, security requirements, and other special requirements.

7.9.1 DOE Decommissioning Experience

Benchmarking data from comparable completed projects across the DOE complex are being compiled for a quick comparison with the FDCM unit cost figures. These benchmarks are detailed in Appendix H. A summary of these benchmarks is shown in Table 7.10 below.

Table 7.10. Summary of DOE Decommissioning Benchmarks

Facility Basis	Type 1 ($/ft^2)	Type 2 ($/ft^2)	Type 3 ($/ft^2)
DOE Benchmarks	$32 - $83	$91 - $637	$217 - $1,455
FDCM	*$26 - $124*	*$180 - $320*	*$239 - $365*

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8

SECTION 8.0
CONTINGENCY ANALYSIS

Cost, schedule, and technical uncertainty represent a large component of the FDCM estimate. This uncertainty is driven by a number of important factors that have traditionally contributed to cost growth, schedule delays, and poor technical performance in large-scale projects.[5]

- **Complexity**: The decommissioning program will address approximately 600 facilities/buildings over a seven-year period (2000 through calendar year 2006) .
- **First-of-a-Kind**: The decommissioning of RFETS will be the first large-scale decommissioning of plutonium contaminated production facilities in the United States.
- **Incomplete Project Definition**: At this stage in the estimating process, the estimate basis for the six remaining T3 and the four significant T2 buildings are not completely developed.

Because of the high degree of uncertainty surrounding the planned decommissioning activities, the range estimating method described in Section 8.2 below was used to develop an appropriate level of cost contingency. This method assigns an uncertainty range around each of the FDCM unit cost estimates. The ranges were determined by a panel of decommissioning specialists for each decommissioning WBS element for each unit cost template. Using Delphi principles, the panel determined the most probable "least" value and the most probable "high" value from the assumed "most likely" value shown in the templates. A specialized software package (*Crystal Ball*) applied Monte Carlo analysis to sample across these ranges and generated a probability distribution.

8.1 RANGE ESTIMATING APPROACH

Range Estimating has been applied to many projects as a means of estimating needed contingency at the task level. The steps used by the FDCM team to develop a range estimate are listed below. Output from the range estimate is included in Appendix I.

- **Develop a List of Uncertainty Factors**: The FDCM team developed a list of the major cost drivers. These categories established the degree of definition surrounding each WBS element and included:
    - Technology
    - Time
    - Interfaces
    - Number of Key Participants
    - Contractor Capability
    - Magnitude and Complexity of Contaminants
    - Regulatory Involvement

[5] R. Shangraw, "Contingency Estimating for Environmental Projects," in Selg, R. A. ed., Hazardous *Waste Cost Control*, New York: Marcel Dekker, Inc., 1993.

- Number of Locations
- Labor Skills and Productivity
- Quality Requirements
- Political Visibility/Public Involvement
- Funding
- Safety

- **Determine the Type of Uncertainty Distribution**: For this analysis, the Wiebel distribution was selected to model the cost uncertainty. This distribution assumes that the actual cost will range between the low and the high estimate and the average cost will be the current unit cost estimate.

- **Quantify the Range of Uncertainty**: For each item in the WBS and for each type of facility, the FDCM team quantified the high, low and most likely range of unit costs. For this analysis, no uncertainty bands were placed around the physical quantities of the facilities (e.g., square feet). The FDCM team used the uncertainty factors above as a framework for establishing the uncertainty bands.

- **Load the Range Information into a Simulation Model**: A simulation package, *Crystal Ball*, was used in conjunction with Microsoft Excel. An Excel spreadsheet was developed for each building type. Ranges were then placed around the unit cost estimates.

- **Simulate Different Scenarios**: Many "trials" can be conducted to simulate reality. These trials use the distributions established above to select an estimate using a random seeding method known as Monte Carlo. Over many trials, the selection of the estimates will follow the distribution established above (in other words, the most likely estimate will be selected most often and the low and high estimates will be selected least often). 5000 trails were run.

- **Evaluate the Results**: After conducting the trials, a probability distribution is constructed for the total estimate. The most likely cost estimate, or the estimate where there is an equal chance of an overrun or an underrun, is the current base estimate. A cost distribution around this most likely estimate is established. This distribution can provide insights into the degree of uncertainty surrounding the current estimate.

9

SECTION 9.0
FDCM RESULTS

Tables 9.1 and 9.2 below present the summary results of the application of Revision 3 of the FDCM to Revision 8 of the RFETS 2006 Facility Disposition Plan. Table 9.1 gives the total decommissioning costs broken down by the eight decommissioning activities plus external tanks, and Table 9.2 gives the total decommissioning costs broken down by structure type.

Table 9.1. Total Decommissioning Costs ($k) by Decommissioning Activity

DECOMMISSIONING ACTIVITY	K-H LABOR HOURS	TOTAL DOLLARS
Planning and Engineering		
Characterization		
Site Preparation		
Decontamination		
Dismantlement		
Demolition and Disposal		
Project Management		
Support Services		
TOTAL		**$910,235.89**

Table 9.2. Total Decommissioning Costs ($k) by Type of Structure

STRUCTURE TYPE	K-H LABOR HOURS	TOTAL DOLLARS
Type 1 Buildings (T1)		
Type 2 Buildings (T2)		
Type 2 Contaminated Buildings (T2CA)		
Type 3 Buildings (T3)		
Type 3 Contaminated Buildings (T3CA)		
Trailers Pre-1989		
Trailers 1989 and Later		
Cooling Towers		
Tents		
Gloveboxes		159,689.26
Piping, Internal Tanks, and Ductwork		
External Tanks		
Sewage Plant		
Infrastructure Facilities/Projects		2,245.46
TOTAL		**$910,235.89**

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Section
10

SECTION 10.0
FUTURE IMPROVEMENTS TO THE MODEL

Future revisions to the FDCM will consider the following suggested improvements in the quantity and quality of the information and input data:

- **Continue the incorporation of actual decommissioning experience and cost information into the model:** Currently, Revision 3 of the FDCM incorporates all the changes previously incorporated into Revision 2/2A and, the actual cost data from the decommissioning of the 207 Cluster, 112 trailers, and the 779 Cluster. Future revisions should include the relevant information from the ongoing efforts to develop detailed bottoms up estimates for 444, 771, 776, 707, and 371. As appropriate and as it becomes available, decommissioning data from other DOE sites and the commercial sector will be considered in future revisions to the FDCM.

- **Improve the Unit Cost Estimates for Different Building Types:** As RFETS continues to decommission additional facilities, actual cost information will be used to improve the basis of the building unit cost templates.

- **Improve the Quantity Estimates for Piping, Ducts, and Internal Tanks:** Approximately xx% of the total direct decommissioning costs are associated with the process piping, ducts, and internal tanks (PD&T) – see Table 9.2. The PD&T decommissioning costs are derived from an assumed exponential relationship between the size of the building's contaminated area, internal process tank volume, and the building's glove box volume. Better methods to quantify these key estimate parameters need to be developed and incorporated.

- **Continuation of the Collection of Actual Decommissioning Cost Data:** As previously mentioned, Revision 3 of the FDCM incorporates actual cost data from current decommissioning projects, e.g. B123, 207 Cluster, and B779. Periodic assessments of cost collection activities are conducted on active decommissioning projects to ensure the required data is obtained in the required format and reported in a timely manner. Steps have been taken to expand the acquisition/reporting of appropriate and relevant actual cost data as more decommissioning projects come on line, e.g., 771, 776.

- **Incorporate Structures Currently Excluded from the FDCM into the Model:** Other structures at RFETS, e.g., stacks, parking lots, overhead pipelines, etc. will have to be decommissioned before the site is closed. Decommissioning of these structures must be added to the FDCM to make it complete.

- **Use of Improved Decommissioning Technologies and Processes:** Although decommissioning is not dependent on the development of any new technology, there are areas where innovative technology may reduce decommissioning costs. Per revision 3, about $42,499.22k of potential glovebox decommissioning cost savings are associated with the inclusion of the Centralized Waste Reduction Facility – see Table M-3. Centralized size reduction technologies could potentially also generate comparable cost reductions in piping, duct, and internal tank decommissioning costs.

- **Dose and Risk-Based Analysis of Decommissioning Alternatives:** The identification of plausible decommissioning alternatives based on dose based residual contamination levels (DCLs) could have a significant impact on decommissioning costs. Decommissioning costs are a function of the decommissioning technology/processes used and the DCLs. Waste disposal costs are in turn affected by the volume of material exceeding the DCL. Revision3 of the FDCM assumes a 50 percent reduction in CA decontamination costs due to adoption of dose based standards. This assumption was judged to be reasonable when data, from an August, 1999, study[1] of the aforementioned subject, was analyzed in detail.

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[1] *The Use of Dose-Based Assessment in Evaluating Decontamination and Decommissioning Alternatives at the Rocky Flats Plant*, August, 1999

Appendix A

Listing of Facilities/Buildings Included in the FDCM

The following tables list all the buildings/facilities at RFETS for which decommissioning costs were developed using the FDCM. The buildings section of the table includes the footprint area and total area of each building. In those cases where the total area is greater than the footprint area, the building has more than one level.

T2 and T3 buildings with contaminated areas (CAs) appear twice on the buildings list, once for the non-contaminated areas and once for the contaminated areas. The sum of the non-CA and CA areas for a building equals the total area of the building.

List of Tables in Appendix A

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Appendix B

Building Factors

The building factor calculations, provided in this appendix, follow the cost estimating and cost accountability system used at RFETS to take into account different working conditions and other task related factors that affect the cost of doing work. The building factor category sheets are based on three principal considerations: Degree of Difficulty, e.g., Height of Work, Work Factor Constraints and Additional Factors, e.g., Building Access Control, Procedural Requirements. “Work Factor Constraints” include, but are not limited to, work location, fatigue, work conditions, etc. The “Additional Factors” are other nonproductive and non project controlled factors that affect both the task cost’s and schedule. Each building type (T1, T2, T2CA, T3, T3CA) was scored using these factors. These factors are used in the FDCM to adjust actual cost experience to different types of buildings. Site experts with extensive knowledge of the working conditions in the different types of buildings completed the scoring.

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Appendix C

Analysis of Costs From Decommissioning Building 123

The decommissioning of Building 123, the first major building to be decommissioned at RFETS, was completed in May 1998. Building 123 was used as an analytical laboratory, dosimeter and instrument calibration facility. The building also was used for medical research, storage for all radiological health records, office space for radiation health specialists, and a laboratory for calibration of criticality alarms.

Building 123 was a Type 2, single story, masonry and steel frame structure with approximately 19,000 square feet. Several other small buildings adjacent to and associated with Building 123 were decommissioned at the same time. These buildings were 113, 114, and 123S.

The decommissioning of Building 123 was accomplished in accordance with the Proposed Action Memorandum (PAM) for the Decommissioning of Building 123, Revision 6, dated March 26, 1998. The PAM provided a detailed description of the tasks for Buildings 113, 114, 123, and 123S. These tasks included decontamination of radiologically contaminated facility systems, partial closure of Resource Conservation and Recovery Act (RCRA) Unit 40 (accomplished using a separate RCRA Closure Plan), and characterization of Individual Hazardous Substance Sites (IHSS) 121 and 148.

Costs for the decommissioning of Building 123 are the basis for a significant portion of the FDCM. The actual costs of decommissioning Building 123 were adjusted to remove costs due to unusual conditions. These unusual conditions include overtime work, work stoppages, delays, non-recurring costs, and unusual building features. For example, Building 123 contained a large steel vault that was removed intact which is not typical of other Type 2 buildings at RFETS. The adjusted actual costs were mapped to the FDCM WBS activities. Unit costs for each WBS activity were calculated from the adjusted actual costs and the area of the building. Table C-1 below provides a breakdown of the actual costs to WBS activity, the adjustments to each activity and the resulting unit costs.

WBS Element	Actual Cost	Basis for Adjustment	Adjusted Cost	Model $/ft^2
Dismantlement	1,654,635	Note 1	1,189,682	61.00
Demolition & Disposal	401,033	Note 2	302,297	15.50
Decontamination	642,537	Note 3	604,593	31.00
Characterization	741,539	Note 4	653,351	33.50
Site Preparation	206,062	Note 5	136,521	7.00
Planning & Engineering	397,483	Note 6	204,782	10.50
Project Management	989,955	Note 7	546,084	28.00
Support Services	992,100	Note 8	526,581	27.00
Total	6,025,344		4,163,890	213.50

Table C-1 Basis of Adjustments to Building 123 Decommissioning Costs

Note 1: The adjustments from $1.7 Million actual costs to $1.2 Million includes a) $44 Thousand of deactivation activities that are not part of the decommissioning scope, b) $160 Thousand for unusual delays, c) $162 Thousand for additional CM associated with the delays and d) $191 Thousand for non-recurring contingency items.

Note 2: The adjustment from $401 thousand to $303 thousand was due to unusual delays during the demolition work.

Note 3: The adjustment from $643 thousand to $605 thousand is due to some unusual conditions that are not anticipated in the future.

Note 4: The adjustment from $741 thousand to $653 thousand is due to some duplication of effort that will not occur in the future.

Note 5: The adjustment from $206 thousand to $137 thousand is due to some unusual conditions that are not anticipated in the future.

Note 6: The adjustment from $397 thousand to $205 thousand is due to some duplication of effort and unusual conditions that will not occur in the future.

Note 7: The adjustment from $990 thousand to $546 thousand is due to some duplication of effort and unusual conditions that will not occur in the future.

Note 8: The adjustment from $992 thousand to $527 thousand is due to delays and unusual conditions that will not occur in the future.

Appendix D

Decommissioning Unit Costs

The tables in Attachment D contain the decommissioning unit cost estimates for each type of facility addressed in the FDCM. Unit costs for each of the applicable decommissioning activities for the different types of structures and different contamination levels are included in the unit cost tables.

Economy of scale factors are used to calculate the total decommissioning costs for multilevel buildings as discussed in Section 7-7. The following equation was developed to determine the scaling factor for each decommissioning activity for multilevel buildings.

$$A_E = A_F \left(\frac{A_T}{A_F} \right)^{EXP}$$

Where: A_E = the effective area of the building
A_F = the footprint area of the building
A_T = the total area of all levels of the building

The exponent used for each of the decommissioning activities, discussed in Section 7-7, are:

DECOMMISSIONING ACTIVITY	EXPONENT
Planning and Engineering	0.20
Characterization	0.20
Site Preparation	0.85
Decontamination	0.85
Dismantlement	0.85
Demolition and Disposal	1.00
Project Management	0.20
Support Services	0.70

The cost for any decommissioning activity for a building is then equal to its effective area times the unit cost for the activity.

The facility unit cost tables in Appendix D are listed on page D-2.

List of Tables in Appendix D

Appendix E

Glovebox Analysis

Estimating the Volume of Gloveboxes

A glovebox includes the electric equipment, pumps, piping, and ductwork that are part of the integral structure of the glovebox. The piping and ductwork terminates at the first flange or connection. Electrical equipment that is connected to the glovebox, but is not bolted or otherwise permanently attached to the glovebox is not considered part of the unit.

The distribution of gloveboxes in RFETS buildings is shown in Table E-1. The glovebox volume data is extracted from the list of site gloveboxes; however, this list does not provide the glovebox volume or capacity for many of the gloveboxes. Table E-1 gives the number of gloveboxes in each building with known volumes and the number of gloveboxes for which the volumes are not known. In order to estimate the total volume of gloveboxes in each of the buildings, the median volume of the glove boxes of known volume in that building was multiplied by the number of gloveboxes of unknown volume. This product was added to the known glovebox volume to obtain the total glovebox volume for that building.

On a building-by-building basis, the glovebox volumes in cubic feet were loaded into BEST as a line item under Dismantlement.

Glovebox decommissioning costs include decontamination, dismantlement, demolition, and disposal costs for the gloveboxes. Decommissioning costs terminate when the glovebox is containerized for shipment or storage as waste.

Building Number	Total No. of Gloveboxes	No. of Gloveboxes with Unknown Volume	Building Median GB Volume	Known Glovebox volume	Total Building Glovebox Volume
371	110	12	120	38,394	39,829
707	172	40	135	38,040	43,435
559	tbd	tbd	tbd	tbd	tbd
771	207	34	38	17,443	18,718
776	64	11	61	74,768	75,442
777	297	4	60	36,187	36,429
886	3	0	1,093	3,280	3,280
Total	Tbd	tbd	tbd	tbd	tbd

Table E-1. Glovebox Distribution in RFETS Buildings

Estimating the Cost of Decommissioning Gloveboxes

The glovebox unit costs used in Revision 3 of the FDCM are based on the recently concluded glovebox decommissioning efforts in Building 779. A total of 133 (11,478 ft^3) Building 779 gloveboxes have been decommissioned at an average direct unit cost of $929/$ft^3$ (see Table E-2). This unit cost is based on actual cost data from Building 779. (A primary assumption of the

FDCM is that unit cost data from B779 will serve as the glovebox decommissioning bench mark until other cost data becomes available.) The current direct unit cost of $\$929/ft^3$ is $\$59.00/ft^3$ more than the glovebox decommissioning unit cost used in Revision 2/2A of the FDCM. This net unit cost increase is due to a change in model assumptions, i.e. a lower actual direct hourly labor fraction of total direct cost versus the assumed fraction in Revision 2/2A and to lower glovebox decommissioning productivity than what was expected and what was observed for the initial Building 779 glovebox decommissioning.

With completion of the 779 decommissioning, total site glovebox volume is now estimated to be $226,133ft^3$ versus the assumed volume of $228,611\ ft^3$ used in Revision 2/2A of the FDCM. The decrease in total glovebox volume ($11,478\ ft^3$) has been partially off set by the addition of 559 glovebox volume not previously accounted for. Therefore, the direct glovebox decommissioning costs have increased $13,52.07k from the glovebox decommissioning costs in Revision 2/2A of the FDCM.

Table E-2. Unit Cost for Glovebox Decommissioning

Element	P&E fraction	PM fraction	SS fraction	Work fraction	Total fraction	Unit Cost ($\$/ft^3$)
Hourly Labor[1]	NA	NA	0.025	0.21	0.235	218.25
Salary Labor	0.10	0.17	0.20	NA	0.47	436.50
MS&E	0.01	0.035	0.04	0.15	0.235	218.25
A5H	NA	0.01	0.02	0.03	0.06	56.00
Totals	0.11	0.215	0.285	0.39	1.00	929.00

[1]The hourly labor unit cost includes a tbd% ($\$tbd/ft^3$) allowance for Overtime

External Tank Analysis

Estimating the Number and Size of External Tanks

The current estimate of external tanks at RFETS is shown in Table F-1 below. This information is based on the Rocky Flats site Tanks By building Report.

Size	Size Criteria	External Tank Type 1		External Tank Type 2	
		Number	Total ft^3	Number	Total ft^3
Small	<1,500 ft^3	177	45,616	30	4,287
Large	> 1,500 ft^3	33	583,660	9	334,281

Table F-1. Estimated Number and Volume of External Tanks at RFETS

Estimating the Unit Cost

The external tank decommissioning process includes mobilization of equipment, preparation costs, and excavation for underground tanks (if necessary), manual cutting of pipes from tanks, tank removal, and equipment demobilization. This work does not include environmental restoration costs (including costs for remediation of leaking tanks). In addition, the cost of draining the tanks of all liquids prior to decommissioning is not included in the decommissioning cost estimate.

Two large diesel fuel storage tanks, Tanks 221 and 224, were demolished and removed from site in FY96. The volume of Tank 221 was 1,850,000 gallons and Tank 224 was 900,000 gallons (total 367,675 cu. ft.). The decommissioning cost incurred was $445K (see ACWP values on attached chart 73805 – Central Steam Plant Renovation) for draining the tanks, characterizing the interior and exterior, tearing them apart with a hydraulic scissors, size reducing the resulting pieces, loading the truck, and disposing of the tank metal at an offsite sanitary landfill. Two storage tanks containing acid were similarly demolished and removed from RFETS during FY96. The volume of each tank was 10,905 gallons (1,458 ft^3).

A Type 2 tank requires additional characterization, documentation, monitoring during all decommissioning phases, and special precautions for disposal. Therefore, the cost of decommissioning a Type 2 tank is expected to cost 1.5 times that of the Type 1 tanks.

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Appendix G

Piping and Duct Analysis

Piping included in the FDCM decommissioning estimate includes all domestic, process, and fire protection water piping (both sanitary and process), process piping (including nitrogen, natural gas, and argon gas), steam piping, and condensate piping. The piping estimate does not include piping associated with gloveboxes. Glovebox piping, which is assumed to terminate at the first flange or valve from the glovebox, is included in the glovebox dismantlement cost estimate. The piping removal activities include equipment setup, insulation removal around cutting areas, cutting, loading cut pipe, and equipment removal.

The estimated cost of removing piping, ductwork, and internal tanks is derived from known costs for removing internal tanks, piping, and ductwork from Building 779. The derivation of the equations relating the cost to remove piping, ductwork and internal tanks in any building to the costs to remove these items in Building 779 is presented below.

DERIVATION OF PIPING/DUCTWORK COST CORRELATION EQUATION

It is assumed that the relationship of the costs to dismantle pipes, internal tanks, and ducts between two buildings is not a linear function of the building areas. It is assumed to be exponential function of the ratios of the contaminated areas, the internal tank volumes, and glove box volumes of the buildings.

The cost to dismantle pipes and internal tanks of building 2 (C_{P2}) is proportional to the product of an exponential function of the ratio of the contaminated area of building 2 (CA_2) to the contaminated area of building 1 (CA_1) and an exponential function of the ratio of the internal tank volume of building 2 (V_{T2}), to the internal tank volume of building 1 (V_{T1}). This is illustrated in the following equation.

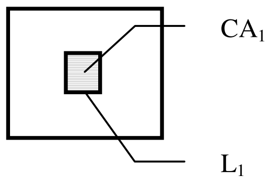
$$C_{P2} = K_P\left(\frac{CA_2}{CA_1}\right)^X\left(\frac{V_{T2}}{V_{T1}}\right)^Y \quad \text{where } K_P \text{ is a constant}$$

The cost to dismantle the ducts of building 2 (C_{D2}) is proportional to the product of an exponential function of the ratio of the contaminated area of building 2 (CA_2) to the contaminated area of building 1 (CA_1) and an exponential function of the ratio of the glovebox volume of building 2 (V_{GB2}), to the glovebox volume of building 1 (V_{TGB1}). This is illustrated in the following equation.

$$C_{D2} = K_D\left(\frac{CA_2}{CA_1}\right)^X\left(\frac{V_{GB2}}{V_{GB1}}\right)^Z \quad \text{where } K_D \text{ is a constant}$$

The calculations to determine the exponents X, Y, and Z follow.

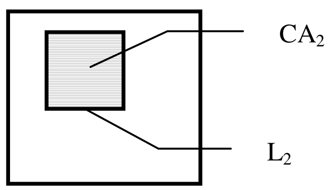
Bldg. 1



L_1 is the length of the side of a square whose area is the same as the CA of building 1. Then $CA_1 = L_1^2$

L_2 is the length of the side of a square whose area is the same as the CA of building 2. Then $CA_2 = L_2^2$

Assume $CA_1 = 100\ ft^2$ and $CA_2 = 300\ ft^2$



Bldg. 2

Then,

$$L_1 = CA_1^{1/2} = 100^{1/2} = 10$$

And

$$L_2 = CA_2^{1/2} = 300^{1/2} = 17.32$$

The ratio of the sides of the squares = L_2/L_1 = 17.32/10 = 1.732

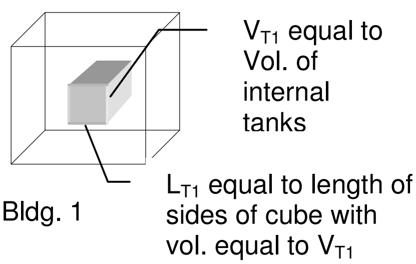
The ratio of the areas of the squares = CA_2/CA_1 = 300/100 = 3

Solving for the CA ratio exponent, X, we have

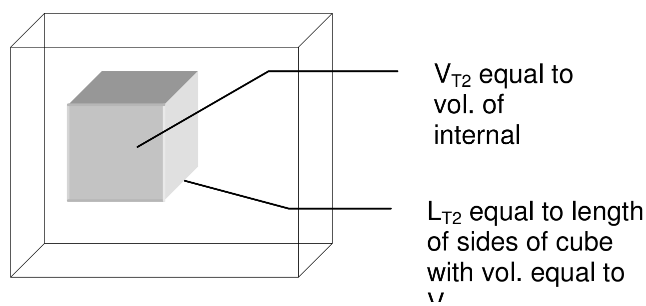
$$\left(\frac{CA_2}{CA_1}\right)^X = 3^X = \frac{L_2}{L_2} = 1.732 \qquad so\ then,\ X = \frac{Ln\ 1.732}{Ln\ 3} = \frac{.549}{1.099} = 0.5$$

For any areas, the ratio exponent always equals 0.5.

The procedure is similar when calculating the exponents Y and Z, the exponents for volume ratios.



Bldg. 1



Bldg. 2

L_{T1} is the length of the side of a cube whose volume is the same as the volume of the internal tanks in building 1. Then $V_{T1} = L_{T1}^3$

L_{T2} is the length of the side of a cube whose volume is the same as the volume of the internal tanks in building 2. Then $V_{T2} = L_{T2}^3$

Assume $V_{T1} = 500\ ft^3$ and $V_{T2} = 2000\ ft^3$

Then,

$$L_{T1} = V_{T1}^{1/3} = 500^{1/3} = 7.937$$

And

$$L_{T2} = V_{T2}^{1/3} = 2000^{1/3} = 12.599$$

The ratio of the sides of the cube = L_2/L_1 = 12.599/7.937 = 1.587

The ratio of the volumes of the cubes = V_{T2} / V_{T1} = 2000/500 = 4

Solving for the V_T ratio exponent, Y, we have

$$\left(\frac{V_{T2}}{V_{T1}}\right)^{Y} = 4^{Y} = \frac{L_2}{L_2} = 1.587 \qquad \text{so then,} \qquad Y = \frac{Ln\ 1.587}{Ln\ 4} = \frac{0.462}{1.386} = 0.333$$

For any volumes, the ratio exponent always equals 0.3333; therefore, the exponent Z is equal to the exponent Y which is .333.

The exponent values derived above are used in the equations relating the cost for decommissioning pipes, internal tanks, and ducts in any building to the cost of these activities in building 779 for which the costs are known.

The contaminated area size, internal tank volume, and glovebox volume for the Types 2 and 3 buildings with contaminated areas are shown in Table G-1 below. Using the above equations, these areas and volumes can be used to calculate the decommissioning costs for the pipes, internal tanks and ducts in these buildings. For calculating the piping and duct removal costs, the glovebox volumes of Building 559 and the T2 buildings are assumed to be the same as the glovebox volume of Building 779 (11,478 ft^3).

Building	Contaminated Area (ft^2)	Internal Tank Volume (ft^3)	Glovebox Volume (ft^3)
Type 3 Buildings			
371	44,327	19,481	39,829
559	14,681	2,603	*tbd*
707	81,960	603	43,435
771	83,100	23,477	18,718
776	88,675	5,514	75,442
777	42,475	576	36,429
Type 2 Buildings			
444	78,908	3,595	0
881	5,098	2,768	0
886	3,550	677	3,280
991	28,410	270	0
Total	**471,184**	**59,564**	***217,133***

Table G-1 Contaminated Area Size, Internal Tank Volume, and Glovebox Volume of all Buildings with Internal Process Piping, Ducts, and Internal Tanks

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Appendix H

Description of the Basis of Estimate Software Tool (BEST) System

Appendix H describes the Basis of Estimate Software Tool (BEST) System. The BEST System collects and stores decommissioning cost data, factors, and quantities; calculates building and site summary and total decommissioning costs; and retrieves FDCM information. BEST is built in Microsoft Access and is comparable to a number of off-the-shelf activity resource estimating packages. K-H uses BEST extensively to support project planning at RFETS. BEST was introduced to the site in 1996 and serves as the primary cost estimating tool for K-H. Additional documentation is available on BEST.[6]

The primary purpose of BEST is to document cost estimates. BEST goals are to:

- Make planning task easier by automating calculations and reducing paperwork.
- Collect data in a standardized format, so that the data can be readily transferred to other information systems.
- Ensure that the data are consistent and validated to the fullest extent possible.

BEST is part of a client/server system. A central database runs on a server while the client program (BEST) runs on the client's personal computer. BEST provides an easy-to-use interface to the server database. Multiple users can access the server data simultaneously.

BEST provides a mechanism to create, modify, and retrieve activity cost estimates and related data. For each activity, any number of line items can be defined. Line items are tasks within an activity. For each line item, any number of bases of estimates (BOEs) can be established. Resources and factors, which are used to compute resource quantities, are easily identified. Costs for each line item of an activity are automatically rolled-up to the activity. BEST provides several types of activity reports.

The data entered using the BEST software is stored in a shared-access database and is accessible by other BEST users. The BEST database stores the cost estimate data for each activity in a BEST project. These projects are used to control the flow of data in BEST - i.e. the "Baseline" project contains the official, approved project data while other projects like "Budcall" and "Change" are used to modify data prior to approval.

Following approval (as in the BCP process), the data from user-changeable projects are uploaded to the "Baseline" project (performed by system administration personnel). BEST controls user update access to the different projects by either locking an entire project from user-initiated change or controlling the updating capabilities according to a user's assigned sub-project (WAD) access rights. Access rights are applied by BEST administration personnel following approval by the assigned "Scheduler" as described below.

The same activity may exist in several projects. For example, an activity may exist in the "Baseline" project while the same activity may also exist in the "Change" project. In this case, a user(s) may be

[6] For additional information on BEST, please see: *Basis of Estimate Software Tool (BEST) User Guide*, May 3, 1998, Version 3.X.

modifying activity data in the “Change” project pending approval and transfer to the official “Baseline” project.

In BEST, there is a special class of users called “Schedulers”. Only users assigned to the “Scheduler” group have the ability to add or delete activities and change certain activity attributes once they have been added to the system. The scheduler group consists of PCIs and certain budget analysts for Kaiser-Hill.

The BEST database provides relational query and report capabilities. The BEST database also exports data to the MicroFrame Program Manager (M*PM) and to the Primavera Project Planner (P3) applications. The BEST database imports WBS data from the WBS in Peoplesoft and schedule data from the P3 application.

Appendix I

Building Decommissioning Benchmarks

The table on page I-2 provides a summary of high-level decommissioning cost benchmarks for completed facilities throughout the DOE complex. In addition, the results of several cost estimating models that include a decommissioning module are included in the table. Additional normalization of these benchmarks is necessary to ensure an accurate comparison between proposed FDCM unit costs and these external projects.

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Appendix J

Output from Range Analysis

An uncertainty range analysis was performed on the FDCM base decommissioning cost estimate. A software program, ***Crystal Ball***, was use to perform this task. The program utilizes the spreadsheet data to provide a picture of the range of possibilities inherent in the data's assumptions. This program operates via a process called Monte Carlo Simulation, which shows an entire range of possible outcomes and the likelihood of achieving each of them. The program uses a random number table or generator to supply the spreadsheet with the possible input data. As the simulation runs, the Model is recalculated for each scenario and the results are dynamically displayed in a forecast chart.

Square foot quantities and cubic foot quantities were entered into an Excel spreadsheet along with the unit rates for this work. The unit rate for each work item was identified as an assumption. Each assumption was assigned a *Weibull* Distribution. In the *Weibull* Distribution the minimum, maximum, and the most likely values were used to determine the mean value. The Standard Deviation was adjusted to match the minimum and maximum values. The resultant distribution is skewed such that the most likely value is the highest value. This distribution provides the range for the calculations to be based upon. The number of trials was set at 5,000. Based on this information and the information in the spreadsheet the program runs the simulation, tabulates the statistical data, and graphs the results.

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Appendix K

Decommissioning Cost Adjustments

Like FDCM Revision 2/2A, a number of changes and initiatives applicable to the decommissioning of facilities at RFETS have been identified and incorporated into the unit costs and/or unit quantities of Revision 3. These changes which impact decommissioning costs are presented below.

K1.0 COST INCREASES INCORPORATED INTO REVISION 3 OF THE FDCM

K1.1 Glovebox Unit Cost Increase and Volume Changes

Revised estimates of the total volume of all gloveboxes at RFETS remaining to be decommissioned have resulted in a net decrease of the total glovebox volume from 228,611ft^3 estimated for Revision 2/2A to 226,133ft^3 in Revision 3. Although 11,478ft^3 of glovebox volume was decommissioned from 779, this was offset by the addition of 9,000ft^3 of glovebox volume from 559 not previously included in the FDCM. The unit costs to decommission gloveboxes has also been revised upward from a base unit cost in Revision 2/2A of \$870/ft^3 to a revised base unit cost of \$929/ft^3. This revised unit cost is based on actual cost data for the decommissioning of gloveboxes in Building 779. These two changes, which have been incorporated into Revision 3 of the model, result in the glovebox decommissioning cost changes shown below.

K1.1.1 Volume Change Cost Impact Due to Inclusion of 559 Gloveboxes

Cost Increase = 9,000ft^3 x \$651.50[1]/ft^2 = \$5,863.50k

[1]See Appendix M for explanation of reduced glovebox unit cost

K1.1.2 Glovebox Unit Cost Changes

The change in the aforementioned glovebox base unit cost adds \$13,052.07k to the decommissioning ETC.

K1.2 Infrastructure Additions

Prior revisions of the FDCM did not include the decommissioning costs for railroad spurs and crossings, perimeter and security fencing, external perimeter and facility lighting, and the removal of ancillary equipment and hardware from the Site's water storage ponds. Previously, the decommissioning costs for these items and infrastructure facilities were the responsibility of Environmental Restoration. Responsibility for this work has been transferred to Decommissioning, and the costs for their decommissioning have been incorporated into the model. The cost impact to the total decommissioning cost estimate for these additions, is \$2,245.46k - see Table K-1.

Item	Cost ($K)
Railroad spurs and crossings	$1,060.75
Perimeter and security fencing	$876.41
Perimeter and external facility lighting	$128.30
Water storage pond hardware	$180.00
TOTAL	**$2,245.46**

Table K-1: Cost Impact of Infrastructure Facilities

K1.3 Revised Facility Assumptions and Changes

Further research of Site documents and review of new data regarding the physical descriptions of RFETS facilities have uncovered numerous changes from Revision 2/2A of the FDCM to the physical parameters used to generate decommissioning cost estimates. These changes, when incorporated into the model, caused a multitude of relatively small cost increases and cost decreases which result in a net cost increase of $1,349.55k to the total decommissioning costs. These changes include:

- Redesignation of building construction type, e.g., from modular to masonry, reinforced concrete to masonry, etc.
- Redesignation of building contamination type, e.g., from T2 to T1, etc.
- Revised footprint areas of buildings.
- Revised total area of buildings and other facilities.

K1.4 Revised Building/Facility Unit Cost Templates

With completion of the 779 and 207 cluster decommissioning projects, it became apparent that the building/facility unit cost templates used in FDCM Revision 2/2A needed to be revised upward. In addition, the unit cost templates for T1 and T2 buildings located in the PA understated expected decommissioning costs for said buildings – see Appendix D. The cost impacts to the Decommissioning ETC for these unit cost changes are shown below:

K1.4.1 T1/T2 Buildings Inside the PA = $9,465.56k

K1.4.2 Increased T1 Unit Costs = $3,027.81k

K1.4.3 Increased T2/2CA Unit Costs = $74,466.83k

K1.4.4 Increased T3/3CA Unit Costs = $107,783.00k

K1.4.5 Increased Cooling Tower Unit Costs = $99.13k

K2.0 COST REDUCTIONS INCORPORATED INTO REVISION 3

K2.1 BEST Adjustments to Revision 2/2A

Since the publication of Revision 2/2A, several BEST input errors were discovered which in total overstated the Revision 2/2A ETC $6,043.66k. Revision 3 of the FDCM incorporates these deductions.

K2.2 Reduced Costs for Process Piping, Ducts, and Internal Process Tanks (PD&T)

During the review of the 779 cluster decommissioning ACWP it was discovered that the size of the Contaminated Area (CA) shown in Rocky Flats Closure Project's Facility List was understated. Said reference indicated the 779 equivalent CA was 5,355 ft^2 whereas the actual equivalent area was calculated to be 38,933ft^2. Since the PD&T costs in the FDCM for the T3CA buildings are based on 779, this change in 779CA size had the effect of reducing the PD&T unit costs and therefore reducing the remaining T3CA building ETC $62,514.11k

K2.3 Reduced ETC Due to Facilities Decommissioned Since Revision 2/2A

Since publication of FDCM Revision 2/2A last year numerous buildings/facilities, e.g., 779 cluster, 112 trailers, have been decommissioned and are therefore no longer on the plant inventory. The FDCM Revision 2/2A direct cost of these facilities was $32,192.75k. These costs have been removed from Revision 3.

K2.4 Reduction in T1/T2 Premium Decommissioning Costs Due to Removal of the Protected Area

Decommissioning ACWP of the 779 cluster indicated that the estimated decommissioning costs for the associated T1 and T2 buildings were significantly understated. The unit cost templates for non PA T1 and T2 did not adequately capture the expected decommissioning costs for these buildings – see xxx. Elimination of the PA, 10/01/02, offers the potential for a reduction of $6,025.82k in the decommissioning unit cost premium for T1 and T2 buildings located in the PA .

K2.4 Reduced Trailer Decommissioning Unit Costs

Based on the ACWP incurred in decommissioning the 112 trailers, the trailer unit costs displayed in previous versions of the FDCM were overstated – see Appendix D. The revised trailer decommissioning unit costs will result in a reduction in the ETC of $5,160

FDCM Rev. 2/2A Base @ $804,518.64k

COST INCREASES			
CHANGE DESCRIPTION	**COST ($k)**	**JUSTIFICATION**	**FDCM SECTION**
Infrastructure additions	2,245.46	Added FDCM Scope	Appendix K
Adjusted facility assumptions	1,349.55	Changed FDCM Assumptions	Appendix K
T1/T2 buildings inside the PA	9,465.56	Changed FDCM Assumptions	Appendix D
Increased T1 unit costs	3,027.81	779 and 788 ACWP	Appendix D
Increased cooling tower unit costs	99.13	Changed FDCM Assumptions	Appendix D
Increased T2/2CA unit costs	74,466.83	779 and 788 ACWP	Appendix D
Increased T3/3CA unit costs	107,783.00	779 and 788 ACWP	Appendix D
559 Glovebox volume added	5,863.50	Previously not included	Appendix M
Glovebox cost increase due to vol. reduction and unit cost change	13,052.07	Changed Model Assumptions, B779 ACWP	Appendix K
TOTAL COST INCREASES	**$217,653.81**		

COST REDUCTIONS			
CHANGE DESCRIPTION	**COST ($k)**	**JUSTIFICATION**	**FDCM SECTION**
BEST adjustments to 2/2A	6,043.66	Errors in Rev. 2/2A EAC	
Reduced Piping, Duct, and Internal Tank (PD&T) Decommissioning Costs	62,514.11	Changed Assumptions, 779 ACWP	Appendix G
FDCM value of facilities decommissioned since last year	32,192.75	Rev. 2/2A 779 and 788 ACWP	
Reduced PA Premium in T2/T3 Bldg. Costs	6,025.82	2006 Schedule, Best Practice	K2.2
Reduced Trailer unit costs	5,160.22	Changed FDCM Assumptions	
TOTAL COST REDUCTIONS	**$111,936.56**		
NET CHANGE (ADDITIONS)	**+$105,717.25**		
Revised FDCM Prime ETC	**$910,235.89**		

Table K-6 Direct Cost Changes Between Revisions 3 and 2/2A of the FDCM

Appendix L

779 Independent Cost Review

The EAC for the 779 Cluster Decommissioning Project would appear to be approximately twice the value predicted by the FDCM Revision 2/2A. When this disparity was determined, the *Project Assistance Corporation* (PAC) was retained by K-H to "perform an independent, critical, and in depth assessment of the of the life-cycle actual and estimated completion costs of the 779 Decommissioning Project." (It should be noted that Building 779 was the first of 7 Type 3 Pu production facilities to be decommissioned at RFETS and the first within the DOE Complex) Although few in number, the six remaining T3 buildings represent $406,545k (45%) of the forecasted total RFETS decommissioning costs. Therefore, any significant growth in the T3 decommissioning costs has major implications to the Site's closure funding requirements.

Superficially, the 779 decommissioning EAC is approximately $35,880k more than the value predicted in FDCM Revision 2/2A. However not all of these increases are valid decommissioning (FDCM) cost increases. The following table summarizes the results of the aforementioned 779 independent cost review and, it captures the major cost increases between the Revision 2/2A forecasted EAC and the actual 779 EAC:

Cost Impact ($k)	**Description**
2,700	Lower productivity, increased resource requirements, more mgt. support for the 4-T1 and 2-T2 buildings associated with the 779 cluster than expected
12,300	Lower productivity, increased resource requirements, more mgt. support costs for both the 779 CA and the cold area than the expected FDCM costs
3,925	Premium time and overtime costs. FDCM Rev. 2/2A unit cost templates have no allowances for premium time or overtime labor costs
1,910	The measured size of the 779 CA was over 7X the size used in the FDCM.
5,710	K-H Team Performance Measure fees are, by definition, excluded from decommissioning
1,105	More work controls and oversight in 779 T2 buildings than expected. Higher fraction of "management support" to "work" than expected.
5,590	More work controls and oversight in both the 779 CA and the cold area than expected. Higher fraction of "management support" to "work" than expected.
675	Higher glovebox costs than the costs predicted by the FDCM
215	Higher piping, duct, and internal tank costs than predicted by the FDCM
1,750	Miscellaneous increases due to changed model assumptions, e.g., elevated walkway, extended schedule, etc
35,880	**TOTAL**

Major K-H conclusions reached by the PAC assessment and which will be incorporated, as appropriate, into Revision 3 of the FDCM are as follows:

- It needs to be recognized that 779 was the first Pu building decommissioned at RFETS and the first within the DOE complex. Therefore, there were no decommissioning cost bench marks or historical decommissioning cost data to reference for this project.

- $5,710k of Performance Measure (PM) fees have been included in the 779 EAC. While they may be valid project charges, they are not valid decommissioning (FDCM) cost increases. Heretofore, PM fees have been excluded from the FDCM.

- $3,925k of premium time and overtime costs have been included in the 779 decommissioning EAC. Like PM fees, these costs have heretofore been excluded from the FDCM. Future revisions to the FDCM may want to include a premium/overtime allowance.

- Based on 779 ACWP, it would appear that the base unit cost templates for Gloveboxes, T1, T2, and T3 buildings are understated and need to be revised for FDCM Revision 3. This is primarily caused by productivity being less than expected and/or increased resource (labor) requirements.

- In addition to the aforementioned productivity and resource issues, there were increased costs associated with PA access issues, Authorization Basis issues, increased management oversight and assessments, and Readiness Reviews.

- The unit cost templates for T1 and T2 buildings are understated for T1/T2 buildings located inside the PA. For Revision 3, separate unit cost templates will be developed for these building types located inside the PA.

- The fractional relationships between the “work” WBS elements versus the “support” WBS elements need to be revised for Gloveboxes, T1, T2, and T3 buildings. A significantly higher fraction of the 779 EAC was spent on support, e.g., Project Management, than previously expected. For Revision 3, these fractional relationships will be revised.

- Although the total PD&T costs for 779 were higher (+$215k) than expected. Overall however, the PD&T unit cost has been reduced. This is due to the fact that the size of the CA was 7X the size previously used in the FDCM. For Revision 3 there should be a major reduction in the PD&T costs compared to Revision 2/2A.

- Based on 779 ACWP (+$675k), glovebox decommissioning unit costs are $59.00/ft^3 higher than the value used in FDCM Revision 2/2A. For Revision 3, the glovebox unit cost will be increased to $929.00/ft^3. This value will be used to calculate the decommissioning costs for all the Site’s remaining gloveboxes.

With exclusion of the aforementioned PM fees and the premium/overtime costs, the net increase in the FDCM 779 cluster burdened lifecycle decommissioning EAC would be about $26,245k. Total 779 cluster burdened decommissioning EAC would therefore be about $60,545k vs. the approximate $34,300k predicted by FDCM Revision 2/2A.

Appendix M

SUPPORTING ANALYSIS

This section describes the basis for the adjustments to the FDCM generated decommissioning ETC. Appendix K lists all the cost increases and cost decreases that were added to or subtracted from the costs in FDCM Revision 2/2A to obtain the total decommissioning costs generated by Revision 3 of $910,235.89k. The net increase from the total direct decommissioning costs of $804,518.64k generated in Revision 2/2A of the FDCM is therefore $105,717.25k.

M1.1 Learning Curve Analysis

RFETS currently has 227 buildings remaining to decommission. It is reasonable to expect that through repetition and as ever increasing amounts of building areas are decommissioned as the Site is closed, unit costs in the model will be reduced. Using Delphi principles, it was the considered opinion of the FDCM development team that as a model input there would be four nominal 5% reductions in the unit costs for T1 and T2 buildings up to a total reduction of about 18.5 percent. This limit is reached when 400,000 ft^2 has been decommissioned. It was also the view of the cost model team that the learning curve reductions for these building types would be in increments of 100,000 square feet of area decommissioned and not be a function of time.

Although there are many similar T1 and T2 buildings, there are only six remaining T3 buildings. Each of the T3 buildings is unique; therefore, T3 buildings do not lend themselves to a learning curve reduction in unit cost. The learning curves for T1 and T2 buildings are calculated and applied separately which means decommissioning experience on T1 buildings is not applicable to T2 buildings and vice versa.

While the decommissioning cost reduction learning curve is a function of the total area decommissioned, the decommissioning of specific types of equipment or process lines such as the decommissioning of glove boxes or internal pipes and ducts is a function of the number of pieces of each type equipment removed. The FDCM does not have a planned reduction of cost (learning curve) for the removal of glove boxes, piping, and ducts. The estimated cost for decommissioning gloveboxes is based on the actual costs incurred by the B779 decommissioning project. The FDCM unit cost of $929/ft^3 for gloveboxes is believed to implicitly incorporate learning curve adjustments.

The learning curve reduction fraction for the decommissioning of buildings in any year is the midpoint of the portion of the curve between the area decommissioned at the beginning of the year and the area decommissioned by the end of the year. As stated above, the learning curve reduction does not begin until 100,000 ft^2 has been decommissioned, and the maximum reduction is four 5 percent increments giving a maximum reduction of 18.55 percent (.95 x.95 x .95 x.95 = 81.45%). In addition, if there is no decommissioning for a full year, the learning curve reverts back to 100 percent.

The following equation is used to determine the midpoint fraction (MPF):

$$MPF = 1/2\left(0.95^{X_C} + 0.95^{X_P}\right)$$

where: X_C = the current exponent which is the cumulative area decommissioned through the current time period divided by 10^5.

X_P = the previous exponent which is the cumulative area decommissioned through the previous time period divided by 10^5.

Calculations using the above equation to determine the midpoint fractions are shown in Table M-1. In the example, 150,000 ft^2 are decommissioned the first year, 100,000 ft^2 the second year, 200,000 ft^2 the third year, and 500,000 ft^2 the fourth year. When the cumulative area decommissioned reaches 400,000 ft^2, a weighted average of the MPF below and above 400,000 ft^2 for that year must be calculated to keep the MPF from going below 81.45 percent. The cost reduction fraction or MPF remains at 0.8145 or 81.45 percent for all periods once the cumulative area decommissioned *over consecutive periods* reaches 400,000 ft^2

Time Period (Fiscal Year)	Area Decommissioned During Time Period (ft^2)	Cumulative Area Decommis-Sioned at End of Period (ft^2)	X_C	X_P	MPF
1	150,000	150,000	1.5	0.0	0.9630
2	100,000	250,000	2.5	1.5	0.9028
3	200,000	450,000	4.0*	2.5	0.8389
4	100,000	550,000	N/A	N/A	0.8145

*See explanation below.

Table M-1 Sample calculations of Midpoint Fractions (MPFs)

Because cost reduction due to the learning curve does not increase once the cumulative area decommissioned reaches 400,000 ft^2, calculation the MPF for the third time period must use the weighted average approach mentioned above. The area decommissioned in period 3 is divided into a 150,000 ft^2 portion (bringing the cumulative area to 400,000 ft^2)and a 50,000 ft^2 portion (the area above 400,000 ft^2).
The equation for period 3 is then:

$$MPF_3 = \left[\frac{0.95^4 + 0.95^{2.5}}{2}\right]\left(\frac{150{,}000}{200{,}000}\right) + 0.8145\left(\frac{50{,}000}{200{,}000}\right) = 0.8389$$

Unlike Rev. 2/2A of the FDCM where they were shown as a separate adjustment, Learning Curve cost reductions are now included in the building ETC values – see Table xx.

M1.2 Time-Phased Incorporation of Building Decommissioning Cost Reductions

Three decommissioning cost reduction initiatives have been phased into the project over time. These initiatives are: use of a learning curve; use of RSOPs; and elimination or reduction in size of the protected area (PA).

It is assumed that use of RSOPs for the decommissioning of all building types (Type 1, Type 2, Type 2CA, Type 3, and Type 3CA) will begin in FY00 and the PA will be eliminated beginning in FY03. As discussed in Section M1.1, learning curve cost reductions for T1, T2, and T2CA buildings are based on completion of 100,000 square foot lots of each building type. The results of the calculations for introduction of RSOPs, elimination of the PA, and use of the learning curve were formed into cost adjustment factors that are applied to decommissioning costs by fiscal year. These building decommissioning unit cost discount factors (or fractions) are shown in Table M-2

.

Fiscal Year	Learning Curve T1 Buildings	Learning Curve T2 Buildings	PA Elimination T2CA Bldgs.	PA Elimination T3CA Bldgs.	Incorporation Of RSOPs
2000	1.00	1.00	1.00	1.00	0.99
2001	1.00	1.00	1.00	1.00	0.99
2002	1.00	0.93	1.00	1.00	0.99
2003	1.00	N/A	0.98	0.96	0.99
2004	0.97	0.96	0.98	0.96	0.99
2005	0.88	0.84	0.98	0.96	0.99
2006	0.81	0.81	0.98	0.96	0.99

Notes: 1) Decommissioning areas by fiscal year for T1, T2, and T3 Buildings are in accordance with Revision 7 of the 2006 Facility Disposition Plan - see attached profile.

2) Learning Curve fractions are calculated per the equation in Section M1.1

3) PA reduction fractions do not apply to T1 buildings, nor to T2 and T3 Administrative Areas (non-CA).

Table M-2 Building Decommissioning Costs Reduction Fractions

M1.3 Reduction in Glovebox Decommissioning Costs

The two initiatives that reduce glovebox decommissioning costs will be phased into the project at different times. These two initiatives are: elimination of the PA which will significantly reduce security requirements; and, use of the Centralized Waste Reduction Facility (CWRF). Current plans estimate that the CWRF will become operational on 4/1/01, and the PA will be eliminated as of the start of FY03 (10/1/02). Thus there are three time periods during which gloveboxes will be decommissioned, one with no cost reduction, one with use of the CWRF facility, and one with both the CWRF facility and no PA. Table M-3 lists the buildings with gloveboxes, and shows the glovebox volume that will be decommissioned in the buildings during each of the three time periods. The table also shows the reduced cost of decommissioning the gloveboxes in each building when the cost reduction factors are applied as well as the total reduced glovebox decommissioning costs.

BUILDING NUMBER	GB VOL. IN FT^3	GB DECOM SCHEDULE START	GB DECOM SCHEDULE DURATION	GB VOL. DECOMMISSIONED (BASE) 10/01/99 – 03/31/01 AT $929/$FT^3$	GB VOL. DECOMMISSIONED (CWRF) 04/01/01 – 09/30/02 AT $717/$FT^3$	GB VOL. DECOMMISSIONED (PA) >10/01/02 AT $651.50/$FT^3$	TOTAL GB DECOM. COST ($K)
371	39,829	04/01/01	42 mos.	N/A	17,070	22,759	27,066.68
707	43,435	10/01/02	NA	N/A	N/A	43,435	28,297.90
771	18,718	10/01/99	48 mos.	7,019	7,019	4,680	14,602.29
776	75,442	10/01/00	36 mos.	12,574	37,721	25,147	55,110.47
777	36,429	10/01/00	36 mos.	6,072	18,214	12,143	26,611.49
559	9,000	>10/01/02	NA	NA	N/A	9,000	5,863.50
886	3,280	>10/01/02	NA	N/A	N/A	3,280	2,143.48
TOTAL	**226,133**			**25,665**	**80,024**	**120,444**	**$159,689.26**
GB DECOMMISSIONING COST PER TIME PERIOD				**$23,842.78K**	**$57,377.21K**	**$78,469.27K**	

(1) Glovebox decommissioning per Revision 8 of the 2006 Facility Disposition Schedule.

(2) Cost reductions for each cost reduction initiative:

- CWRF: (226,133 – 25,665) X (929 – 717) = $42,499.22k
- PA: 120,444 X (717– 65150) = 7,889.08k

Total Savings $50,388.30k

Table M-3 Glovebox Cost Reductions Due to Centralized Waste Reduction Facility (CWRF) and Elimination of the Protected Area (PA)

Attachment 1

2006 Facility Disposition Plan

Revision 8

May, 1999

Prepared for:

Rocky Flats Operations Office
U.S. Department of Energy
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